SECTION 500

STRUCTURES

500.1 GENERAL

This section defines the various construction items that are associated with the completion of a concrete, steel, timber, or masonry unit structures, or a combination thereof.

500.2 CONTENTS

SECTION 501
EXCAVATION AND BACKFILL FOR STRUCTURES

501.1 GENERAL

The work performed under this specification shall include, but not be limited to providing the equipment, labor and materials for the excavation and backfill of areas related to structures, such as bridges, foundations, walls, storm drain inlets, as specified on the plans and therein or as authorized by the ENGINEER.

501.2 REFERENCES

501.2.1 American Society for Testing Materials (Latest Edition)(ASTM)

C136 Test for Sieve or Screen Analysis of Fine and Coarse Aggregate
D422 Particle-Size Analysis of Soils
D423 Test for Liquid Limit of Soils
D424 Test for Plastic Limit and Plasticity Index of Soils
D698 Moisture-Density Relations of Soils Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in.(305mm) Drop
D1140 Amount of Materials In Soils Finer Than No.200(75um)Sieve
D1557 Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb(4.54-kg)Rammer and 18-in. (457mm) Drop
D2922 Density of Soil and Soil Aggregate In-Place by Nuclear Methods
D3017 Moisture Content of Soil and Soil Aggregate In-Place by Nuclear Methods
D4253 Maximum Density of Soils using a Vibratory Table
D4254 Minimum Index Density of Soils and Calculation of Relative Density

501.2.2 This Publication:
Section 207 Lean Fill Construction
Section 301 Subgrade Preparation

501.3 EXCAVATION

501.3.1 All excavation for structures shall be made in accordance with applicable regulations such as the Department of Labor's Occupational Safety and Health Administration Standards 29CFR Part 1926, Subpart P or any applicable amendments.

501.3.2 When slope limit for structural excavation is shown on the plans, those limits are to establish the pay quantities for structural excavation and backfill only and in no way shall relieve the CONTRACTOR from meeting the requirements of 501.3.1 above.

501.3.3 The bottom width of the excavation shall be a minimum of the bottom width of the structure foundation plus one foot (1') on each side to provide space for erection and removal of forms. Additional bottom area may be required due to the type and size of compaction equipment the CONTRACTOR chooses to use.

501.3.4 CONTRACTOR shall be responsible for obtaining and maintaining a temporary storage site for usable excavated material during the period of construction. CONTRACTOR may request through the ENGINEER, approval of the OWNER to store excavated material within the street right-of-way or on City property.

501.4 COMPACTED BACKFILL

501.4.1 Backfill material shall be either Class I, II, III, or Class IV soils as defined in TABLE 501.4.A, or Lean Fill complying with the requirements of Section 207. The CONTRACTOR shall not place backfill against a portland cement concrete structure until the concrete has attained 80% of the design strength as determined by the average strength of two field cured cylinders. The field cured cylinders shall be cured in the field under the same condition as the concrete in the structure, represented by the cylinders.

501.4.2 The CONTRACTOR shall remove unsuitable material which either will not compact readily or serve the intended purpose and replace it with suitable material as authorized by the ENGINEER.

501.4.3 All forms, braces, and debris shall be removed before start of backfilling.

501.4.4 Backfill material shall be placed in level lifts and each compacted lift shall not exceed 6 inches.

501.4.5 Soil used for the backfill around structures shall be compacted to a dry density of not less than 90% of maximum dry density in a moisture range of optimum moisture +/-2% as determined in accordance with ASTM D1557 (modified), unless the soil contains 35% or more finer than the No. 200 sieve. If the soil used has 35% or more finer than the No. 200 sieve, it shall be compacted to a dry density of 90% of maximum dry density in a moisture content range of at least optimum moisture to +4% above optimum as determined in accordance with ASTM D698 (Standard).

501.4.6 When structural backfill is within the roadway area, this area shall be compacted to 90% dry density as specified in 501.4.5 and rework and compacted to 95% dry density at the same time as the surrounding subgrade area is compacted as specified in Section 301.

501.5 GRAVEL DRAINS

501.5.1 The construction plans may require the installation of weep holes in the concrete walls to relieve the surcharge pressure of ground water. Gravel drains are intended to provide a drainage course to the weep holes. The size, shape, and

TABLE 501.4.A

EMBEDMENT SOILS CLASSIFICATIONS

SOILS CLASS	SOIL TYPE	DESCRIPTION
CLASS I SOILS*		Manufactured angular, granular material, 1/4 to 1-1/2 inches (6 to 40 mm) size, including materials having regional signficance such as crushed stone or rock, broken coral, crushed slag, cinders, or crushed shells, complying to the requirements of Class II soils.
CLASS II SOILS**	GW	Well-graded gravels and gravel-sand mixtures, little or no fines. 50% or more of coarse fraction retained on No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
CLASS II SOILS**	GP	Poorly graded gravels and gravel-sand mixtures, little or no fines. 50% or more of coarse fraction retained on No. 4 sieve. More than 95% retained on No. 200 sieve. Clean
CLASS II SOILS **	SW	Well-graded sands and gravelly sands, little or no fines. More than 50% of coarse fraction passes No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
CLASS II SOILS**	SP	Poorly graded sands and gravelly sands, little or no fines. More than 50% of coarse fraction passes No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
CLASS III SOILS***	GM	Silty gravels, gravel-sand-silt mixtures. 50% or more of coarse fraction retained on No. 4 sieve. More than 50% retained on No. 200 sieve.
CLASS III SOILS***	GC	Clayey gravels, gravel-sand-clay mixtures. 50% or more of coarse fraction retained on No. 4 sieve. More than 50% retained on No. 200 sieve.
CLASS III SOILS***	SM	Silty sands, sand-silt mixtures. More than 50% of coarse fraction passes No. 4 sieve. More than 50% retained on No. 200 sieve.
CLASS III SOILS***	SC	Clayey sands, sand-clay mixtures. More than 50% of coarse fraction passes No. 4 sieve. More than 50% retained on No. 200 sieve.
CLASS IV SOILS	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands. Liquid limit 50% or less. 50% or more passes No. 200 sieve.
CLASS IV SOILS	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. Liquid limit 50% or less. 50% or more passes No. 200 sieve.
CLASS IV SOILS	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
CLASS IV SOILS	CH	Inorganic clays of high plasticity, fat clays. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
CLASS V SOILS	OL	Organic silts and organic silty clays or low plasticity. Liquid limit 50% or less. 50% or more passes No. 200 sieve.
CLASS V SOILS	OH	Organic clays of medium to high plasticity. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
CLASS V SOILS	PT	Peat, muck and other highly organic soils.

* Soils are as defined in ASTM D2487, except for Class I Soil which is defined in ASTM D2321.
** In accordance with ASTM D2487, less than 5% passes No. 200 sieve.
***In accordance with ASTM D2487, soils with 5% to 12% passing No. 200 sieve fall in a borderline classification that is more characteristic of Class II than of Class III.

location of the gravel drain will be shown on the construction plans.

501.5.2 Gravel drain material shall consist of a material complying with the following gradation, and having the same or similar gradation curve as defined by the specification limits when graphically plotted on a standard aggregate gradation chart.

SIEVE SIZE	% PASSING
3 inch	100
1/2 inch	70 - 100
no. 4	50 - 80
no. 16	25 - 50
no. 50	5 - 15
no.200	0 - 5
Liquid Limit	NV (no value)
Plasticity Index	NP (non plastic)

**The drain material shall comply with the following material size ratios:

$$12 < / = R50 < / = 58$$

$$R50 = \frac{\text{50-percent size GDM}}{\text{50-percent size BM}}$$

$$12 < / = R15 < / = 40$$

$$R15 = \frac{\text{15-percent size GDM}}{\text{15-percent size BM}}$$

where

GDM - represents the Gravel Drain Material
BM - represents the Base Material (surrounding soil)

501.5.3 A separator (membrane type) geotextile fabric shall be used to encase the Gravel Drain Material in areas where the surrounding soild has 30% or greater of its material passing the no. 200 sieve.

501.6 MEASUREMENT AND PAYMENT

501.6.1 Measurement:

501.6.1.1 Unless specified on the plans, in the Supplemental Technical Specification and/or in the Bid Proposal no separate measurement will be made for excavation and backfill for structures. This work shall be considered incidental to and part of the cost of the structure.

501.6.1.2 When specified on the plans, in the Supplemental Technical Specifications and/or in the Bid Proposal excavation and backfill for structures shall be measured by the cubic yard of excavation.

501.6.1.3 Gravel drains will be measured by the cubic foot based on the neat line volume shown on the plans or as authorized by the ENGINEER.

501.6.2 Payment:

501.6.2.1 Payment for excavation and backfill for structures shall be made at the contract unit price per structure or per cubic yard of excavated quantity, complete in place, which price shall include all equipment, labor and materials required to excavate, stock pile, backfill, compact, and the removal and disposal of excess material.

501.6.2.2 Payment for gravel drains shall be made at the contract unit price per cubic foot, complete in place, which price shall include all equipment, labor and materials required in furnishing the gravel and geotextile fabric, the installation of both and the compaction required.

SECTION 502

DRIVING PILES

502.1 GENERAL

The driving of piles will comply with the specifications contained in this section. The type and location of piles to be installed shall be shown on the construction plans. The specifications for the various types of piles are included in Sections 150, 151, and 152.

502.2 REFERENCES
This Publication:
SECTION 150
SECTION 151
SECTION 152

502.3 INSTALLATION

502.3.1 Piles driven under this specification shall be accurately spaced and driven either vertically or to the prescribed batter, as indicated on the plans; no greater variation from the vertical or specified batter line than 1/4 of an inch per foot of length being permitted. Piles otherwise driven and those seriously damaged in driving shall be removed or cut off and replaced with new piles. Should any pile be raised by the subsequent driving of others, it shall be redriven.

502.3.2 The pile top elevations shown on the plans are approximate and are to be used as a basis for establishing quantities for piling, including exploratory piles, for bidding purpose only.

502.3.3 When required in the Supplementary Specifications, one pile of the type selected or designated for the work shall be driven in each pier and abutment area as an exploratory pile. The location of these piles shall be determined by the ENGINEER.

502.3.4 The conditions under which the exploratory piles will be driven shall be as ordered by the ENGINEER. These exploratory piles shall be furnished and driven by the CONTRACTOR and under normal circumstances shall be left in place and utilized as one of the specified piles.

502.3.5 Exploratory piles shall be driven with the same size and type hammer operating with the same effective energy and efficiency as that to be used in driving the remainder of the piles.

502.3.6 The purpose of driving the exploratory piles is to determine the length and penetration that will be required in the balance of the piles. Therefore, no piles other than the exploratory piles shall be driven at each pier or abutment area until such determination has been made by the ENGINEER and has been reported to the CONTRACTOR.

502.3.7 The ENGINEER shall order the top elevation to which the piling shall be driven for the particular pier or abutment. All piles shall be driven to the top elevation as established by the ENGINEER or deeper if necessary to develop the prescribed bearing value as determined by the formula hereinafter prescribed.

502.3.8 Required excavations in the areas through which the piles are to be driven shall be made before any pile is driven therein. NO excavation may be made below the bottom of the pile footing elevation, unless approved by the ENGINEER.

502.3.9 When piles are to be driven through bridge approach embankment and the depth of the embankment at the pile location is in excess of 5 feet, the pile shall be driven in a hole drilled through embankment. The hole shall have a diameter of not less than the butt diameter of the pile plus 6 inches. After driving the pile, the annular space around the pile shall be filled to ground surface with dry sand or pea gravel.

502.3.10 No piles shall be driven within 25 feet of any concrete that has not attained a minimum compressive strength of 2000 psi.

502.4 PILE DRIVING EQUIPMENT AND OPERATIONS

502.4.1 No piles shall be driven, no piles shall be jetted, and no pile holes shall be drilled unless the ENGINEER is present during the operation.

502.4.2 All piles shall be protected during driving with an approved driving head. The tops of timber piling shall be trimmed to fit the driving head, and the piles shall be protected against brooming and splitting. Timber piles shall be pointed (4 inches square point) or shod with metal shoes when required. A cushion block approved by the ENGINEER shall be used. In case the metal pile top folds, corrugates, or is otherwise damaged due to impact of the hammer blow,

the CONTRACTOR may be required to reinforce the top of the pile.

502.4.3 Unless otherwise provided, bearing piles shall be driven with a pile hammer delivering not less than 15,000 foot pounds of energy per blow, except timber piling may be driven with drop hammers or pile hammers having an energy rating not less than 6,800 foot pounds. Pile hammers shall be operated at speeds recommended by the manufacturer.

502.4.4 Gravity hammers for timber piles shall weigh approximately 3,000 pounds, except that the hammer shall not weigh more than 3,500 pounds. The maximum drop shall not exceed 10 feet. When the hammer fails to produce the required bearing, the ENGINEER may permit 5 blows at not to exceed 36,000 foot pounds of energy per blow as a final check of bearing obtained. The CONTRACTOR shall furnish the ENGINEER with a certified scale weight of the hammer to be used. Steam, air, or diesel hammers for driving timber piling shall develop an energy of not less than 6,800 foot pounds of the manufacturer's rated energy.

502.4.5 Pile driver leads shall be constructed so as to afford freedom of movement to the hammer and shall be held firmly in position by guys, stiff braces, or other effective method to prevent swinging and to support the pile in driving and insure the hammer blow being delivered squarely on the end of the pile. When driving batter piles, the lead shall be inclined and effectively braced so as to remain in line with the desired position of the pile. The driving of piles by the use of followers will not be permitted without written permission of the ENGINEER.

502.4.6 When approved by the ENGINEER, the CONTRACTOR may supplement driving equipment with a water jetting plant without extra compensation. The number of jets and the volume and pressure of water at the jet nozzle shall be sufficient to freely erode the material adjacent to the pile. The plant shall have a sufficient capacity to deliver at all times at least 325 g.p.m at 100 pounds pressure per square inch at two 3/4 inch nozzles. Before the desired penetration is reached, the jets shall be withdrawn and the pile shall be driven by the manner to obtain the final penetration and bearing.

502.4.7 Piles shall be driven to not less than the minimum penetration elevation shown on the plans, unless otherwise permitted by the ENGINEER. Piling shall be driven to at least the design bearing shown on the plans, unless otherwise directed by the ENGINEER. Timber piling shall not be driven to a computed bearing in excess of 50 tons.

502.4.8 When approved by the ENGINEER, water jets or drilling may be used in conjunction with the hammer to obtain the specified penetration. If possible, the last 3 feet of penetration shall be obtained by driving without the use of water jets.

502.4.9 Test blows, to determine average penetration, shall be applied after the jets have been removed. The use of water jets will not modify any of the requirements of this section.

502.4.10 Unless drilled holes are shown on the plans, holes other than starting holes shall not be drilled until the ENGINEER has determined that piling cannot be driven, except where piling is to be placed in compacted fill at abutments.

502.4.11 When permitted by the ENGINEER, pilot holes may be drilled to an elevation sufficient to allow driving the pile to at least minimum penetration elevation, but not more than full specified length, providing that such may be accomplished without injury to the pile and full bearing is achieved. Where piling is to be placed in compacted fill at abutments, when permitted by the ENGINEER, pilot holes may be drilled to the natural ground elevation prior to attempting to drive the piling. All drilled pilot holes will be considered incidental to the completion of the work and no measurement or payment will be made therefor.

502.4.12 The drilling of holes shall be done by approved methods and in such manner that the piles will be accurately positioned as shown on the plans.

502.4.13 Unless larger hole is permitted by the ENGINEER to obtain minimum penetration, the diameter of the drilled holes shall not exceed the following:

502.4.13.1 Timber Piles--One inch larger than the average between the tip and butt diameters.

502.4.13.2 Pipe Piles--The outside pile diameter.

502.4.13.3 "H" Piles--Two inches smaller than the diagonal measurement of the pile.

502.4.14 When a pile is set in a hole larger than the diameter of the pile, the portion of the hole in solid material

shall be filled with Class A concrete and the portion of the hole above solid material may be filled with sand or other suitable material. These materials will be considered incidental to the completion of the work and no direct payment will be made therefor.

502.4.15 The ENGINEER shall make an inspection to determine if shooting with explosives or redesign is necessary when piles cannot be driven or holes drilled. Shooting of holes with explosives will not be allowed without written permission.

502.4.16 Driven pilot holes may be used to loosen and break up the compacted strata to such an extent that the piles may be driven to the required depth through the driven pilot holes.

502.4.17 Abutment bearing piles shall not be driven until the approach embankment material, underneath and adjacent to the abutment, has been placed and compacted to the required density. The surface of such approach embankment, after compaction, shall be not less than the elevation of the bottom of the abutment.

502.4.18 When steel pipe piling are included in the work, the CONTRACTOR shall have available at all times a suitable device, of a type approved by the ENGINEER, for thoroughly illuminating the interior of the pipe piles for their entire length after they have been driven. Any pipe pile that shows breaks, deformations, or other defects that would impair the strength or efficiency of the completed pile shall be pulled or abandoned if approved by the ENGINEER and replaced at the CONTRACTOR's expense.

502.4.19 After steel pipe piles have been driven to final penetration, such piles will be given a final inspection. Any water or other foreign substance inside the piles shall be removed. Upon approval of the driven piles by the ENGINEER, such piles shall be filled with concrete. The initial deposit in the pipe shall be 2 or 3 cubic feet of Portland cement mortar, which shall be followed by deposits of concrete in layers not more than 3 feet in depth and each layer shall be compacted by rodding or by other approved methods before a succeeding layer is placed. The work of placing and compacting the concrete shall be carried on continuously in successive layers until the entire pipe pile is completely filled. The schedule for driving piles shall be such as to avoid vibrations and pressure reaching piles or other structural components in which concrete has been placed and taken initial set but has not attained sufficient strength to resist damage.

502.5 COMPUTATIONS FOR BEARING VALUES

502.5.1 In the absence of loading tests, the bearing value of a pile will be determined as herein provided. When required by the ENGINEER, a pile shall be left to set for a period not to exceed 24 hours and again driven to determine the safe bearing value.

502.5.2 Each structural steel pile, steel pipe pile, or timber pile driven without a core or mandrel shall have a bearing value determined as follows:

502.5.2.1 Gravity hammers:

$$P = \frac{2\ WH}{S + 1.0}$$

502.5.2.2 Single-acting steam, air, or diesel hammers having open ends:

$$P = \frac{2\ WH}{S + 1.0}$$

502.5.2.3 Double-acting steam, air, or diesel hammers having enclosed ends:

$$P = \frac{2E}{S + 1.0}$$

502.5.2.4 Where:

P = Allowable safe bearing value in pounds.
W = Weight in pounds of striking parts of the hammer.
H = Height of fall or stroke of the ram in feet.
E = Manufacturer's rated energy in foot pounds per blow at the rated speed for double acting steam or air hammers.

502.5.2.5 E = Ninety percent of the average equivalent energy in foot pounds as determined by a gauge attached to the hammer and recorded during the period when the average penetration per blow is recorded, for diesel hammers having enclosed rams. Hammers of this type shall be equipped with a gauge and applicable charts supplied, which will evaluate the equivalent energy being produced under any driving condition, otherwise the formula for diesel hammers with open end will apply.

502.5.2.6 S = Average penetration in inches per blow during the last 10 to 20 blows.

502.5.3 Steel pile shells driven with a core or mandrel, the bearing value of a single pile will be determined by one of the formulas herein provided:

502.5.3.1 Single-acting steam, air, or diesel hammers having open ends:

$$P = \frac{2WH}{S + \frac{0.1(w)}{W}}$$

502.5.3.2 Double-acting steam, air, or diesel hammers having enclosed ends:

$$P = \frac{2E}{S + \frac{0.1(w)}{W}}$$

502.5.3.3 Where:

(w) = Weight of the pile including the weight of the core or mandrel in pounds.

502.5.4 The formulas in Subsections 502.5.2 and 502.5.3 are applicable only when:

502.5.4.1 The gravity hammer has a free fall.

502.5.4.2 The penetration is at a reasonably quick and uniform rate.

502.5.4.3 The lifting line on the hammer is slack so that the whole weight of the hammer is on the pile.

502.5.4.4 There is no appreciable bounce after the blow. Twice the height of the bounce shall be deducted from "H" to determine its true value in the formulas.

502.5.4.5 The head of a wood pile is free from broomed or crushed wood fiber.

502.5.4.6 A follower is not used.

502.6 TOLERANCES AND REJECTION

502.6.1 Piles, preparatory to driving, shall be located accurately in the correct position. During the driving, the pile shall be held in its correct position by adequately braced leads, a heavy template, struts, cables, toggles, or other approved methods.

502.6.2 Foundation piling shall be driven with a maximum variation of not to exceed 1/4 inch per foot from the vertical or from the batter shown, with the head of the pile varying not to exceed 6 inches from the plan position. These tolerances may be waived by the ENGINEER if, in his opinion, the conditions made such tolerances impractical and the capability of the structure is not impaired by exceeding the tolerances given. Foundation piling shall not be driven until after the excavation is approximately complete.

502.6.3 Trestle piling shall be driven with a maximum variation of not to exceed 1/4 inch per foot from the vertical or batter shown, with the pile varying not to exceed 3 inches from the plan position. These tolerances may be waived by the ENGINEER if, in his opinion, the conditions make such tolerances impractical and the capability of the structure is not impaired by exceeding the tolerances given.

502.6.4 Piles broken by reason of internal defects or by improper driving or driven out of the tolerances allowed will be rejected. When permitted by the ENGINEER, a second pile may be driven adjacent to the rejected pile, provided such second pile is driven without detriment to the structure; otherwise the rejected pile shall be removed and replaced. The removing and replacing of a rejected pile or the furnishing and driving of a second pile adjacent to a rejected pile will be considered incidental to the completion of the work and no measurement or payment will be made therefor.

502.6.5 The tops of all piles shall be cut off normal to the pile or to the bevel shown on the plans and to the elevations established by the ENGINEER.

502.6.6 Structural steel piles and steel pipe piles shall be accurately cut off at the required elevation. Steel pipe piles shall be cut off before being filled with concrete.

502.7 TIMBER PILES WITH TIMBER CAPS

Timber piles which support timber caps shall conform to the plane of the bottom of the superimposed cap. Wedging or shimming between the pile and cap will not be permitted. The heads of all treated and untreated timber piles for trestles, after driving and cutting off, shall be treated by either method herein provided. Heads of piling encased in concrete do not require either of the following treatments:

502.7.1 A coat of hot creosote oil shall first be applied to the head of the pile and a protective cap then built up by applying alternate layers of loosely woven fabric and hot asphalt or tar, using 3 applications of asphalt or tar

and 2 layers of fabric. The fabric shall measure 6 inches more in each direction that the pile diameter and shall be turned down over the pile neatly trimmed, and the edges secured by binding with 2 turns of No. 10 galvanized wire. The fabric shall be wired in advance of the final coat of asphalt or tar which shall extend down over the wiring.

502.7.2 Three coats of hot creosote oil shall first be applied to the head of the pile followed by 1 coat of hot roofing pitch. Each coat shall be allowed to become practically dry before applying the succeeding coat. A covering of 20 gauge galvanized sheet metal shall be placed over the pitch coating. The cap material shall measure not less than 6 inches more in each direction than the diameter of the piling and shall be turned or bent down over the pile. The edges shall be neatly trimmed and secured to the pile with large-head galvanized nails.

502.8 STEEL PILE COLUMNS

Steel pile columns shall be placed in dug or drilled holes at locations, batters, and elevations shown on the plans. After placement, steel pipe pile columns shall be filled with concrete and painted as herein provided:

502.8.1 Steel pile columns shall be set plumb or to the batter shown on the plans. Variation greater than 1/8 inch per foot from the vertical or batter line indicated will not be permitted. The top of the pile shall not be out of the position shown on the plans by more than 1 inch.

502.8.2 Closed-end pipe pile columns shall be placed to bear directly on the solid rock or shale at the bottom of the excavation. When required, a layer of Portland cement mortar shall be deposited on the bottom of the excavation on the cleaned surface of rock or shale to provide a full bearing for the closed end of the pipe. Mortar deposited under water shall be placed by means of a suitable tremie. In case the excavation is dry or is dewatered, open-end pipe pile columns may be used when approved by the ENGINEER. When open-end pipe pile columns are used, the top of the rock or shale at the bottom of the excavation shall be thoroughly cleaned before placing the columns.

502.8.2.3 After steel pipe pile columns have been placed in final position, they shall be given a final inspection. Any water or other foreign substance inside the pipe shall be removed. Upon approval by the ENGINEER, the pipes shall be filled with concrete. The initial deposit in the pipe shall be 2 or 3 cubic feet of Portland cement mortar, which shall be followed by deposits of concrete in layers not more than 3 feet in depth and each layer compacted by rodding or by other method satisfactory to the ENGINEER before a succeeding layer is placed. The work of placing and compacting the concrete shall proceed continuously in successive layers until the entire pipe is completely filled.

502.9 BEARING PILE LOAD TEST

502.9.1 General

When required, this work shall consist of a test load on a driven pile to determine the bearing capacity and settlement behavior of the pile. The pile load test shall be conducted under the supervision of the ENGINEER.

502.9.2 Test Methods

502.9.2.1. The CONTRACTOR shall apply the test load concentrically by such method that the test load acting on the pile may be accurately determined and controlled at any time. The CONTRACTOR shall submit the method of anchorage and loading to the ENGINEER, for approval prior to beginning any test.

502.9.2.2 The CONTRACTOR shall furnish accurate gauges and devices for determining the load applied and shall furnish the ENGINEER with a certificate of calibration of the gauges or devices from an approved laboratory prior to use.

502.9.2.3 The CONTRACTOR shall furnish the ENGINEER with adequate facilities for making load and settlement readings 24 hours per day, except such engineering instruments and apparatus normally used by the ENGINEER.

502.9.2.4 The load shall be applied to the pile as near the ground surface as practicable or as designated by the ENGINEER. If the load is applied on a pile projecting appreciably above ground, care shall be taken to prevent failure by column action. Test piles shall be vertical within the tolerances provided. Test loading results will not be accepted when pile fails structurally during test loading due to faulty installation or procedure by the CONTRACTOR.

502.9.2.5 After load testing is completed, test piles and anchor piles shall be used as bearing piles, unless rejected

by the ENGINEER. Rejected test piles and anchor piles shall be removed by the CONTRACTOR at his expense.

502.9.2.6 Test load shall be applied not less than 24 hours after test pile and anchor piles have been driven. When test loading pipe piles, the test piles and anchor piles shall not be loaded until the concrete has attained a compressive strength of not less than 2,400 psi. The ENGINEER may require all piles to be driven within the test area before the test pile is test loaded. The load shall be applied in increments as herein provided. The first load application shall be approximately 4/5 of the design bearing capacity in tons as shown on the plans. Additional load increments of 10 tons each shall be applied not less than 1 hour after all measurable settlement due to previous loading has been determined. Such load increments shall be applied, as herein provided, until the load test has been completed. Measurable settlement is defined as settlement of 1/8 inch or more subsequent to an intermediate reading.

502.9.2.7 Readings of the amount of settlement will be made by the ENGINEER immediately before and after the application of each load increment and at intermediate intervals 20 minutes apart. Such readings and corresponding load increments and total load will be recorded.

502.9.2.8 The application of load will be considered complete when the gross settlement of the loaded pile reaches the yield point, except when the yield point is reached before the total load equals 1.6 times the design load of the pile as shown on the plans. Yield point is defined as when the additional amount of settlement exceeds 0.02 inch per ton for the increment applied. When this amount of settlement per increment occurs before the total load equals 1.6 times the design bearing capacity, an additional similar increment of load shall be applied to determine if this amount of settlement per increment is repeated or exceeded. If this amount of settlement per increment is repeated or exceeded, the application of load will be considered complete; but if not, the application of increments will be continued until yield point occurs or until the maximum amount of load required is applied.

502.9.2.9 The CONTRACTOR will not be required to apply a total load greater than 3 times the design bearing capacity in tons, unless otherwise shown on the plans or in the Supplementary Specifications.

502.9.2.10 When the yield point in the settlement has not been reached after the last increment of load required has been applied, the application of the total load shall be continued for not less than 12 hours after all measurable settlement has ceased.

502.9.2.11 Immediately after the total load is removed from the pile, the net settlement will be recorded by the ENGINEER. Not less than 3 hours after the total load is removed from the pile, the settlement will again be recorded by the ENGINEER.

502.9.2.12 When it becomes necessary, due to unforeseen conditions, to remove and reapply any of the test load, such application shall be made gradually in increments approved by the ENGINEER.

502.10 MEASUREMENT AND PAYMENT

Measurement and payment of the various items will be as follows:

502.10.1 Splices for structural steel piles, structural steel pile columns, steel pipe piles, and steel pipe pile columns will be considered incidental to the completion of the work and no measurement or payment will be made therefor.

502.10.2 Pile load tests will be measured as follows:

502.10.2.1 First pile load test.

502.10.2.2 Each subsequent pile load test.

502.10.3 All pile cut-offs will be considered incidental to the completion of the work and no measurement or payment will be made therefor.

502.10.4 Piles that have been driven or partially driven and subsequently ordered removed by the ENGINEER will be considered incidental to the completion of the work and no measurement or payment will be made therefor.

502.10.5 When drilled holes for bearing piles are called for on the plans, such drilled holes will be measured to the nearest vertical foot.

502.10.6 Metal shoes for timber piling, authorized by the ENGINEER and furnished by the CONTRACTOR, will be measured by the unit per each.

502.10.7 All jetting and all pilot holes will be considered incidental to the completion of the work and no measurement or payment will be made therefor.

502.10.8 Test piles driven and not included in the permanent structure will be measured to the nearest vertical foot. Payment will be made at the unit price per vertical foot per type of pile as indicated in the Bid Proposal.

502.10.9 Piles of approved length, furnished and not driven, will be measured to the nearest linear foot. Payment will be made at the unit price per foot per type of pile as indicated in the Bid Proposal.

502.10.10 All piles of the various types and lengths permanently incorporated in the structure will be measured to the nearest vertical foot after cut-off.

502.10.11 Concrete placed in steel pipe piles or steel pipe columns will be measured to the nearest 1/10 cubic yard. Payment will be made at the unit price per cubic yard as shown in the Bid Proposal.

502.10.12 Steel reinforcement placed in steel pipe piles or steel pipe columns will be measured by the pound. Payment shall be made at the unit price per pound as stated in the Bid Proposal.

SECTION 503
SUBDRAINAGE

503.1 GENERAL

The work performed under this specification shall include, but not limited to providing the equipment, labor and materials for the excavation, installation and backfilling of subdrainage improvements as specified on the plans and herein or as authorized by the ENGINEER.

503.2 REFERENCES

503.2.1 American Society for Testing Materials (Latest Edition)(ASTM)

F758 Smooth Wall Poly (Vinyl Chloride) (PVC) Plastic Underdrain System for Highways, Airports, and Similar Drainage

503.2.2 This Publication:
Section 101 Portland Cement Concrete
Section 121 Plastic Pipe
Section 920 Sanitary and Storm Sewer Manholes
Section 1502 Submittals

503.4 SUBDRAINAGE PIPE

Subdrain pipe unless specified on the plans or in the Supplemental Technical Specifications as solid wall pipe shall be perforated pipe as specified in ASTM F 758. Solid wall pipe shall be in accordance with Section 121.

503.5 PIPE JOINTS AND FITTINGS

503.5.1 All pipe and fitting joints shall be the rubber gasket type in accordance with Section 121. No "open joints" will be permitted on the subdrain pipe.

503.5.2 All fittings used on subdrain piping shall be the rubber gasket type, having the same or better strength as the pipe required and be approved by the pipe manufacturer for use on the pipe.

503.6 SUBDRAINAGE MANHOLES

Subdrain manholes shall be as detailed on the plans and shall be in accordance with Section 920.

503.7 FILTER AND DRAIN MATERIALS

503.7.1 A separator (membrane type) geotextile fabric as specified on the plans or in the Supplemental Technical Specification shall be used to encase the gravel drain material.

503.7.2 Gravel drain material shall consist of a material complying with the following gradation, and having the same or similar gradation curve as defined by the specification limits when graphically plotted on a standard aggregate gradation chart.

SIEVE SIZE	% PASSING
3 inch	100
1/2 inch	70 - 100
no. 4	50 - 80
no. 16	25 - 50
no. 50	5 - 15
no.100	0 - 15
Liquid Limit	NV (no value)
Plasticity Index	NP (non-plastic)

**The drain material shall comply with the following material size ratios:

$$12 < / = R50 < / = 58$$

$$R50 = \frac{\text{50-percent size GDM}}{\text{50-percent size BM}}$$

$$12 < / = R15 < / = 40$$

$$R15 = \frac{\text{15-percent size GDM}}{\text{15-percent size BM}}$$

where

GDM-represents the Gravel Drain Material
BM -represents the Base Material (surrounding soil)

503.8 PLACEMENT

503.8.1 The area in which the subdrain is to be installed shall be backfilled, compacted and re-excavated or excavated to the line and grade shown on the plans for the drain material.

503.8.2 The geotextile fabric shall be placed in the trench so as to form a continuous cover on all four (4) sides of the gravel drain material after it is placed, with a minimum of a one-foot (1') overlap on the top of the gravel. If the length of the subdrain is longer than the geotextile fabric, the fabric may be installed with a two-foot (2') overlap with the upstream end laid under the downstream end.

503.8.3 The gravel drain material shall be placed in the bottom, on top of the fabric, up to or a few inches above the grade of the pipe. The pipe shall be installed to the line and grade shown on the plans or as authorized by the ENGINEER. Gravel drain material shall be placed around and on top of the pipe as shown on the plans. The geotextile fabric shall be placed over the top of the gravel with a minimum of a one-foot (1') overlap.

503.8.4 The upstream end of the subdrain pipe shall be left open until the placement steps outlined above have been completed. Water shall be introduced into the upstream end of the pipe to flush out any debris in the pipe. The amount of water needed will

depend on the condition of the pipe. After flushing the end of the pipe shall be capped and the gravel drain material and fabric placed around the end of the pipe.

503.8.5 Upon completion of the above steps, one foot (1') of fill shall be placed over the subdrain area and additional fill placed and compacted as specified for fill, or subgrade, etc. The first foot of fill over the subdrain will not be tested for compaction.

503.9 SUBMITTALS

The CONTRACTOR shall submit the information specified in Section 1502 on the pipe, fittings, gravel, and fabric.

503.10 MEASUREMENT AND PAYMENT

503.10.1 Subdrain shall be measured by the linear foot along the centerline of the pipe and through all fittings.

503.10.2 Payment for subdrain shall be made at the contract unit price per linear foot complete in place which price shall include all equipment, labor and materials required to excavate and install the pipe, fittings, gravel drain material, and geotextile fabric.

SECTION 510

CONCRETE STRUCTURES

510.1 GENERAL

Concrete structures, such as: bridges, culverts, storm inlets, retaining walls, abutments, piers, footings, foundations and similar structures, shall be constructed in conformity with these specifications and the construction plans.

510.2 REFERENCES

510.2.1 This Publication:

Section 101 Portland Cement Concrete
Section 102 Steel Reinforcement
Section 103 Epoxy-Coated Steel Reinforcement
Section 105 Concrete Curing Compound
Section 107 Joint Filler and Sealant Material
Section 337 Portland Cement Concrete Pavement
Section 349 Concrete Curing
Section 501 Excavation and Backfill for Structures
Section 502 Driving Piles

510.2.2 Others

PS-1-66 Specifications for Plywood, U.S. Products Standard, U.S. Department of Commerce.

Standard Specifications for Welding for Highway and Railroad Bridges, American Welding Society.

510.3 MATERIALS

510.3.1 CONCRETE

Concrete for use in work constructed under this section shall conform to the requirements of Section 101 and as shown on the plans or as specified in the Supplementary Technical Specifications and approved by the ENGINEER.

510.3.2 STEEL REINFORCEMENT

Reinforcement bars shall conform to the requirements specified in Section 102 and 103.

510.4 SUBGRADE FOR CONCRETE STRUCTURES

Earth subgrade upon which concrete is placed shall be firm and free from water and/or frost. All subgrade on which Structural concrete is to be placed shall be compacted to the minimum density specified in Section 501 or on the plans. Ground water shall be kept twelve (12") inches below the subgrade until the concrete has set. When the subgrade is in dry earth, it shall be moistened with water from a spray nozzle immediately before concrete is placed. When the design details for the project provide for the construction of filter or drain material consisting of gravel or combination of gravel and sand, which material becomes subgrade for concrete, the placing of steel reinforcement and pouring of concrete shall follow the placing of the filter or drain material as closely as practical. The filter or drain material shall be kept dewatered to the extent necessary to prevent any portion of concrete materials being carried away before the concrete has attained its final set. When concrete is to rest on rock, the rock shall be fully uncovered. The surface of the rock shall be removed to a depth sufficient to expose sound rock. Bedrock shall be roughly leveled off or cut to approximately horizontal and vertical steps. Seams in the rock shall be grouted as directed by the ENGINEER and the base for structures shall be slush grouted or otherwise treated as the ENGINEER may direct.

510.5. FORMS

510.5.1 Forms shall be of suitable material and of type, size, shape, quality, and strength to enable construction as designed. The forms shall be true to line and grade, mortar tight, and sufficiently rigid to resist any appreciable amount of springing out of shape during placing of the concrete. The responsibility for their adequacy shall rest with CONTRACTOR. All dirt, chips, sawdust, nails, and other foreign matter shall be completely removed from forms before any concrete is deposited therein. The surfaces of forms shall be smooth and free from irregularities, dents, sags, and holes that would appreciably deface the finished surface. Forms previously used shall be thoroughly cleaned of all dirt, mortar, and foreign matter before being reused, and the reuse of forms shall be subject to approval of the ENGINEER. Before concrete is placed in forms, all inside surfaces of the forms shall be thoroughly treated with an approved releasing agent that will leave no objectionable film on the surface of the forms that can be absorbed by the concrete. Care shall be exercised that no releasing agent is deposited on previously placed concrete. Forms for all surfaces that will not be completely enclosed or hidden below the permanent surface of the ground shall be made of surfaced lumber or material which will provide a surface at least equally satisfactory. Any lumber or material which becomes badly checked or warped prior to placing concrete may be rejected. Forms for all exposed surfaces of bridges, viaducts, over crossings, and similar structures shall be constructed of plywood or an approved equal. Plywood for forms shall conform to the specifications of the U.S. Department of Commerce, U.S. Product Standard PS 1-66 Class I or II. All form panels shall be placed in a neat, symmetrical pattern with the horizontal joints level and continuous. Unless otherwise shown on the plans, all exposed edges shall have a 3/4 inch chamfer. Forms for curved surfaces shall be so constructed

and placed that the finished surface will not deviate appreciably from the arc of the curve. Forms shall be so constructed that portions, where finishing is required, may be removed without disturbing portions of form to remain. Form clamps or bolts approved by the ENGINEER shall be used to fasten forms. The use of twisted wire loop ties to hold forms in position will not be permitted, nor shall wooden spreaders be used unless authorized by the ENGINEER. Clamps or bolts shall be of sufficient strength and number to prevent spreading of the forms. They shall be of such type that they can be entirely removed or cut back 1 inch below the finished surface of the concrete. Forms for outside surfaces shall be constructed with stiff wales at right angles to the studs and all form clamps shall extend through and fasten such wales. The CONTRACTOR may, at his own option, place such portions of the concrete directly against the sides of the excavation or sheathing without the use of outside forms, provided that the following conditions are met:

510.5.1.2 If concrete is placed against sheathing, such sheathing shall be closely fitted and shall be outside of the concrete lines shown on the plans. Those surfaces against which the concrete is placed shall be faced with building paper. Except as otherwise specified hereinafter, all sheathing shall be removed but not until either at least 7 days after placing concrete or until the concrete has attained sufficient strength to support itself and any load that may be placed on it.

510.5.2 Care should be used in pulling sheathing so as to avoid damaging the concrete. Voids left by the removal of sheathing, piles, and/or similar sheathing supports shall be backfilled with material having a sand equivalent of not less than 30 and consolidated. When, in the opinion of the ENGINEER, field conditions or the type of sheathing or methods of construction used by the CONTRACTOR are such as to make the removal of sheathing impracticable, that portion of the sheathing against which concrete has been placed shall be left in place.

510.5.3 Regardless of the method used in placing concrete without outside forms, the following stipulations shall hold:

510.5.3.1 The reinforcing steel shall be accurately set and held firmly in place, to the satisfaction of the ENGINEER.

510.5.3.2 The CONTRACTOR shall assume all risks of damage to the work or to existing improvements due to any reason whatsoever that may be attributable to the method of construction outlined above.

510.5.3.3 Should the method of construction of placing directly against the sides of the excavation or sheathing without use of outside forms not prove satisfactory in the opinion of the ENGINEER, the CONTRACTOR shall discontinue said method of construction and construct the structure by using outside forms.

510.6 FALSEWORK

All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads. Falsework for the support of a superstructure shall be designed to support the loads that would be superimposed were the entire superstructure placed at one time. All falsework, staging, walkways, forms, ladders, cofferdams, and similar accessories shall equal or exceed the minimum applicable requirements of the Federal and State statutes and local ordinances. Compliance with such requirements shall not relieve the CONTRACTOR from full responsibility for the adequacy and safety of said items. Falsework shall be founded upon a solid footing safe against undermining and protected from softening. When the falsework is supported on timber piles, the piles shall be driven to a bearing value as determined by the formula specified in Section 502, equal to the total calculated pile loading. Falsework and forms shall be so constructed as to produce in the finished structure the lines and grades indicated on the plans. Suitable jacks or wedges shall be used in connection with the falsework to set the forms to grade or camber shown on the plans or to take up any settlement in the formwork either before or during the placing of the concrete. However, single wedges for this purpose will not be permitted, it being required that all such wedges be in pairs to insure uniform bearing. Dead load deflection in stringers and joists will be compensated for by varying the depth of the joists or by using varying depth nailing strips. Arch centering shall be removed uniformly and gradually beginning at the crown and working toward the springline to permit the arch to take its load slowly and evenly. Centering for adjacent arch spans shall be struck simultaneously. Falsework under any continuous unit or rigid frame shall be struck simultaneously, the supporting edges being released gradually and uniformly starting at the center and working both ways toward the supports.

510.7 REMOVAL OF FORMS

510.7.1 The falsework supporting any span of a continuous or rigid frame structure subject to bending stress shall not be released until after the last concrete placed in the span and in the adjoining spans (excluding concrete above the deck slab) has attained a compressive strength of not less than 80 percent of its design strength or 21 days after the concrete is placed, whichever occurs first. Stairway riser forms shall be removed and the finish of the steps completed on the day the concrete is poured. Metal stairway treads, if required by the plans, shall be installed immediately after the steps have

been poured. Forms and falsework supporting the bottom slab of the superstructure of box girder structures shall remain in place until the curing period of the deck of the superstructure has expired. Forms for the webs of box girders shall be removed before the deck slab is poured. Forms for the upper deck slab which are to remain in place shall be supported by bolts through the girder webs or some equally satisfactory method that will prevent the transfer of any load to the lower deck slab. Forms supporting the concrete deck slab of box girders may be left in place. All interior forms in box girders, except those permitted to remain in place, shall be completely removed and the inside of the box girder. Side forms for beams, girders, columns, railings, or other members wherein the forms do not resist dead load bending may be removed after a period of 36 hours, unless otherwise directed by the ENGINEER, provided that satisfactory arrangements are made to cure and protect the concrete thus exposed in accordance with Section 349. Side forms for arch rings, columns, and piers shall be removed before the members of the structure which they support are placed so that the quality of the concrete may be inspected. Such forms shall be so constructed that they may be removed without disturbing other forms which resist direct load or bending stress.

510.7.2 The periods of time at which the CONTRACTOR may remove forms, as set forth in this Section, are permissive only and subject to the CONTRACTOR assuming all risks that may be involved in such removals. At his option, the CONTRACTOR may leave the forms in place for such longer periods as are, in his opinion, required.

510.8 PLACING REINFORCEMENT

Reinforcing bars shall be accurately placed as shown on the plans and shall be firmly and securely held in position by wiring at intersections and elsewhere as necessary to prevent shifting of bars, with wire not smaller than No. 16, and by using concrete or metal chairs, spacers, metal hangers, supporting wires, and other approved devices of sufficient strength to resist crushing under full load. The use of wooden supports will not be permitted. Placing bars on layers of fresh concrete as the work progresses and adjusting bars during the placing of concrete will not be permitted. Before placing reinforcing steel in the forms, the reinforcing steel shall be thoroughly cleaned of mortar, oil, dirt, loose mill scale, loose or thick rust, and coatings of any character that would destroy or reduce the bonds. No concrete shall be deposited until the placing of the reinforcing steel has been inspected and approved.

510.9 SPLICING

Splices of bars shall be made only where shown on the plans or as approved by the ENGINEER. Where bars are spliced, they shall be lapped at least 20 diameters for deformed bars, unless otherwise shown on the plans. Welding of reinforcing steel will be permitted when authorized by the ENGINEER in writing and shall be in accordance with the American Welding Society (Standard Specifications for Welding for Highway and Railroad Bridges).

510.10 BENDING REINFORCEMENT

Bends and hooks in bars shall be made in the manner prescribed by the American Concrete Institute. Bars shall not be bent nor straightened in a manner that will injure the material. Bars with kinks or unspecified bends shall not be used.

510.11 WELDED WIRE FABRIC

Welded wire fabric shall be held firmly in place. Welded wire fabric shall be spliced not less than two meshes.

510.12 PLACING CONCRETE

510.12.1 Where a schedule for placing concrete is shown on the plans, no deviation will be permitted therefrom unless approved in writing by the ENGINEER. The placing of concrete for a given area shall start at the low point and shall proceed upgrade, unless otherwise permitted by the ENGINEER. With the exception of concrete placed in slope paving and aprons and concrete placed under water, all concrete shall be compacted by means of high frequency internal vibrators of a type, size, and number approved by the ENGINEER. The number of vibrators employed shall be ample to consolidate the incoming concrete to a proper degree within 15 minutes after it is deposited in the forms. In all cases, at least 2 vibrators shall be available at the site of the structure in which more than 25 cubic yards of concrete is to be placed. The vibrators shall not be attached to or held against the forms or the reinforcing steel. The locations, manner, and duration of the application of the vibrators shall be such as to secure maximum consolidation of the concrete without causing segregation of the mortar and coarse aggregate and without causing water or cement paste to flush to the surface. Fresh concrete shall be spread in horizontal layers insofar as practicable, and the thickness of the layers shall not be greater than can be satisfactorily consolidated with the vibrators. If additional concrete is to be placed, care shall be taken to remove all laitance and to roughen the surfaces of the concrete to insure that fresh concrete is deposited upon sound concrete surfaces. Layers of concrete shall not be tapered off in wedge-shaped slopes but shall be built with square ends and level tops.

510.12.2 Mixed concrete, after being deposited, shall be consolidated until all voids are filled and free mortar appears on the surface. The concrete shall be placed as nearly as possible in its final position.

The use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted. Fresh concrete shall not be permitted to fall from a height greater than 6 feet without the use of adjustable length pipes or "elephant trunks" or "Trimmies." The use of approved external vibrators for compacting concrete will be permitted when the concrete is inaccessible for adequate compaction, provided the forms are constructed sufficiently rigid to resist displacement or damage from external vibration. During the placing of concrete, care shall be taken that methods of consolidation used will result in a surface of even texture free from voids, water, or air pockets and that the coarse aggregate is forced away from the forms in order to leave a mortar surface. Spades or broad-tined forks shall be provided and used to produce the desired results if required by the ENGINEER. The use of chutes in conveying or depositing concrete will be allowed only at the discretion of the ENGINEER; and wherever they are used, they shall be laid at such inclination as will permit the flow of concrete of such consistency as is required. The use of additional water in mixing the concrete to promote free flow in chutes of low inclination will not be allowed. Where necessary in order to prevent segregation, chutes shall be provided with baffle boards or a reversed section at the outlet. Columns shall be poured preferably through pipes of adjustable length and not less than 6 inches in diameter. Horizontal members or sections shall not be placed until the concrete in the supporting vertical members or sections has been consolidated and settlement has occurred.

510.13 JOINTS

The work shall be so prosecuted that construction joints will occur at designated places shown on plans unless specifically permitted otherwise by the ENGINEER. The CONTRACTOR shall complete, by continuous depositing of concrete sections of the work comprised between such joints. The joints shall be kept moist until adjacent concrete is placed. All construction joints at the bottom of walls or arches, at the top of walls, and all longitudinal construction joints having a keyed, stepped, or roughened surface shall be cleaned by sandblasting prior to pouring the adjacent concrete. Any quality of sand may be used which will accomplish the desired results. Other methods of cleaning joints may be used provided the method and result is approved by the ENGINEER. Joint cleaning operations shall be continued until all unsatisfactory concrete and all laitance, coatings, stains, debris, and other foreign materials are removed. The surface of the concrete shall be washed thoroughly to remove all loose material. The method used in disposing of waste water employed in washing the concrete surfaces shall be such that the waste water will not stain, discolor, or affect exposed surfaces of the structure. The method of disposal will be subject to the approval of the ENGINEER. All horizontal construction joints or those on slight slopes shall be covered with mortar. Expansion and contraction joints in the concrete structures shall be formed where shown on the drawings and as directed by the ENGINEER. In general, such joints shall have smooth abutting surfaces, painted, or separated and sealed in accordance with Section 107 or as detailed on the plans. No reinforcement shall be extended through the joints, except where specifically noted or detailed on the plans.

510.14 PLACING CONCRETE UNDER ADVERSE WEATHER CONDITIONS

Concrete for structures shall not be placed on frozen ground nor shall it be mixed or placed while the ambient temperature is below 40°F. Concrete shall not be placed during rainfall unless adequate protection is provided. Upon written notice from the ENGINEER, all concrete which may have become damaged due to adverse weather conditions, shall be replaced by the CONTRACTOR at no expense to the OWNER.

510.15 SURFACE FINISHES

The classes of surface finish described hereafter shall be applied to various parts of concrete structures as specified. Bridge decks shall be finished in conformity with Section 337. When required by the ENGINEER, the CONTRACTOR, prior to placing of concrete, shall provide a test section for evaluation of the surface finish to be employed. There will be no separate payment made for the test sections.

510.15.1 ORDINARY SURFACE FINISH

510.15.1.1 Immediately after the forms have been removed, all exterior form bolts shall be removed to a depth of at least 1 inch below the surface of the concrete and the resulting holes or depressions cleaned and filled with mortar, except on the interior surfaces of box girders the bolts shall be removed flush with the surface of the concrete. Mortar shall consist of 1 part by volume of cement to 2 parts of sand. Mortar shall be mixed approximately 45 minutes in advance of use. Care shall be exercised to obtain a perfect bond with the concrete. After the mortar has thoroughly hardened, the surface shall be rubbed with a carborundum stone in order to obtain the same color in the mortar as in the surrounding concrete. All fins caused by form joints and other projections shall be removed and all pockets cleaned and filled. Mortar for filling pockets shall be treated as specified for bolt holes.

510.15.1.2 In the judgment of the ENGINEER, if rock pockets or other defects are of such extent or character as to affect the strength of the structure materially or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of the structure affected.

510.15.1.3 Ordinary Surface Finish shall be applied to all concrete surfaces either as a final finish or preparatory to a higher class finish. Ordinary Surface Finish, unless otherwise specified, shall be considered as a final finish on the following surfaces:

510.15.1.3.1 The undersurfaces of slab spans, box girders, filled spandrel arch spans, and floor slabs between T girders or superstructures not for grade separation structures.

510.15.1.3.2 The inside vertical surface of T girders or superstructure not for grade separation structures and the exposed surfaces of channel walls.

510.15.1.3.3 Surfaces which are to be buried underground or covered with embankment and surfaces above finished ground of culverts where not visible from the traveled way.

510.15.1.4 On surfaces which are to be buried underground or surfaces which are completely enclosed, such as the cells of box girders, the removal of fins and form marks and the rubbing of mortared surfaces to a uniform color will not be required.

510.15.2 CLASS 1 SURFACE FINISH

510.15.2.1 After completion of the Ordinary Surface Finish, the entire surface specified shall be sanded with a power sander or other approved abrasive means as required to obtain a uniform color and texture. The use of power carborundum stones or discs will be required to remove unsightly bulges or irregularities. The Class 1 Surface Finish shall be applied after the removal of forms. The object of these operations is to obtain a smooth, even surface of uniform appearance and to remove unsightly bulges or depressions due to form marks and other imperfections. The degree of care in building forms and the character of materials used in formwork will be a contributing factor in the amount of such sanding and grinding requirement, and the ENGINEER shall be the sole judge in this respect.

510.15.2.2 Class 1 Surface Finish as hereinafter specified shall be applied to the following surfaces unless otherwise specified in the Supplementary Technical Specifications.

510.15.2.2.1 All surfaces of superstructures for grade separation structures.

510.15.2.2.2 All exposed surfaces of bridge piers, columns and abutments, and retaining walls and to at least 1 foot below finished grade.

510.15.2.2.3 The outside vertical surfaces and bottom surface of outside girders and the under surfaces of cantilever sidewalks, safety curbs, and floor slabs overhanging outside girders only of superstructures not for grade separation structures.

510.15.2.2.4 All surfaces of open spandrel arch rings, spandrel columns, and abutment towers.

510.15.2.2.5 Exposed surfaces of culvert headwalls and retaining walls, where visible from a traveled way.

510.15.2.2.6 Surfaces inside of culvert barrels having a height of 4 feet or more for a distance inside the barrel at least equal to the height of the culvert.

510.15.2.2.7 All interior surfaces of pump house motor and control rooms and engine generator rooms.

510.15.3 CLASS 2 SURFACE FINISH

Class 2 Surface Finish as hereinafter specified shall be applied to the following surfaces unless otherwise specified in the Supplementary Specifications: all surfaces of concrete railing, including barrier railing, rail posts, rail end posts, and rail base. When Class 2 Surface Finish is specified, the Ordinary Surface Finish and Class 1 Surface Finish shall be completed in succession. The process specified under Class 2 Surface Finish shall then be deferred until all other work, which would in any way affect or mar the final finish, is complete. The CONTRACTOR shall then apply a brush coat or surface film of thin cement mortar composed of 1 part Portland cement and 1 part of fine sand of such size that it will pass a No. 16 sieve or, at the option of the ENGINEER, a neat cement wash. In either case, an amount of calcium chloride equal to 5 percent by volume of the cement shall be used in the brush coat. When the cement film has set sufficiently so that the sand particles or cement will not drag out of surface pin but before the final set has taken place, the entire surface shall be thoroughly rubbed either by hand or by mechanical means with fine carborundum stone until a smooth surface of even texture, color, and appearance is obtained. No greater amount of mortar shall be applied in advance of rubbing than can be completely rubbed before final setting takes place. Immediately following the rubbing process, the finished surface shall be thoroughly washed with water.

510.16 CURING

Immediately after the completion of the finishing operations as the condition of the concrete will permit without danger of consequent damage thereto, the CONTRACTOR shall initiate the curing of the concrete as specified in Section 349 and/or as approved by the ENGINEER.

510.17 TESTS

Testing procedures shall be as provided for in Section 101. The number of test

specimens to be taken for compression tests shall be as specified in Section 101 or as otherwise required by the ENGINEER.

510.18 MEASUREMENT: Structural Concrete for Concrete Structures shall be measured by the cubic yard or as part of a lump sum item as indicated in the Bid Proposal.

510.18.2 PAYMENT: The payment for Structural Concrete shall be at the contract unit price per cubic yard or lump sum, complete in place. Payment shall include all material, equipment and labor required in forming, supporting, placing, finishing, curing, form and support removal, and cleanup.

SECTION 511

PNEUMATICALLY APPLIED CONCRETE

511.1 GENERAL

Pneumatically applied mortar or concrete, designated herein as gunite or approved equal, shall consist of premixed sand and portland cement pneumatically transported in a dry state to a nozzle where hydration takes place immediately prior to expulsion.

511.2 REFERENCES

511.2.1 ASTM
C 39
C 42

511.2.2 This publication
SECTION 105

511.3 EQUIPMENT

511.3.1 The cement gun should be operated at a minimum air pressure of 45 pounds per square inch on the gun tank when 100 feet or less of material hose is used, and the pressure should be increased 5 pounds for each additional 50 feet of hose required. Nozzles used for applying the material shall have a maximum size of 1 5/8 inches unless otherwise permitted by the ENGINEER.

511.3.2 Water used for hydration shall be maintained at a uniform pressure, which shall be at least 15 pounds per square inch above air pressure at the gun.

511.4 PROPORTIONS AND MIXING

Unless otherwise specified, the material shall consist of a mixture of cement and sand in the proportions, by volume, of 1 part of cement to 4 1/2 parts sand. The sand and cement shall be thoroughly mixed in a power mixer for at least 1 1/2 minutes before placement in the chamber of the gun. The dry mixed material shall be used promptly after mixing, and any material that has been mixed for more than 45 minutes shall be wasted.

511.5 TESTS

511.5.1 During the applicaton of the material, the CONTRACTOR shall cooperate with the ENGINEER in making compressive tests required to determine the quality of the material being placed in the work. The tests shall be conducted in conformity with the requirements of ASTM C 39. Test specimens shall be made so as to represent the quality of material being placed in the work by each nozzleman and shall consist of 6 inches x 12 inches cylinders made by shooting the material vertically into cylindrical cages of 1/2 inch mesh hardware cloth mounted on a board. The material outside the mold should be removed immediately after shooting the specimen so that the wire mesh can be detached before testing. The number of test specimens to be taken shall be as provided in the Supplementary Specifications or as determined by the ENGINEER. Separate test specimens made at the same place and time shall be tested at the age of 7 and 28 days. The specimens at the age of 7 days shall develop a minimum compressive strength of 2,400 pounds per square inch, and at the age of 28 days the specimens shall develop a minimum compressive strength of 3,500 pounds per square inch unless otherwise specified herein. In lieu of the above tests, the ENGINEER may elect to perform core tests. A minimum of 3 cores shall be taken for each 250 cubic yards or fraction thereof of material deposited.

511.5.2 Cores shall be obtained and tested in accordance with ASTM C 42. One core shall be removed and tested at an age of 14 days, the other 2 cores at an age of 28 days. Fourteen day cores shall develop a minimum strength of 2,200 psi. Twenty-eight day cores shall develop a minimum strength of 3,000 psi unless otherwise specified herein.

511.5.3 If the cores show deficient strength, additional cores shall be taken at the CONTRACTOR's expense from adjacent areas. Two cores shall be required for each deficient core. Should such deficiency be evident in 14 day cores, on approval of the ENGINEER, the CONTRACTOR may proceed with the work on his own responsibility until the 28 day cores are tested.

511.5.4 Where conditions preclude the possibility of obtaining cores from the material in place, the ENGINEER may approve cores taken from a respresentative test panel made at the same time and under the same conditions as the material being placed in the work.

511.6 PLACEMENT

511.6.1 Earth surfaces to which the material is to be applied shall be neatly trimmed to line and grade and shall be free of all loose material. The surface need not be compacted by slope rolling or other measures unless required by the plans or Supplementary Specifications.

511.6.2 No high subgrade will be permitted and excavation made below subgrade shall be backfilled with compacted fill or, at the CONTRACTOR's option, with

the material. However, no additional compensation will be allowed for such compacted fill nor for increased thickness of material placed on account of low subgrade.

511.6.3 Asphaltic concrete surfaces shall be thoroughly cleaned of any growth, silt and clay, or any other material detrimental to the material and then washed with water under pressure.

511.6.4 Masonry, rock, and concrete surfaces shall be examined and all loose material removed therefrom. The surface shall be thoroughly cleaned with steel scrapers or brushes to remove all dust, dirt, mortar, grease, or other deleterious substances and then washed with water.

511.6.5 Whenever brushing and scraping do not secure suitable results, sandblasting may be required.

511.6.6 All surfaces shall be wetted with water before application of the material, and no material shall be applied to surfaces on which free water exists.

511.6.7 The velocity of the material as it leaves the nozzle shall be maintained uniformly at a rate determined for given job conditions. Material which rebounds and does not fall clear of the work or which collects on the surfaces shall be blown off or otherwise removed. Rebound shall not be used in any portion of the work, and no pavement will be incorporated for rebound or other losses.

511.6.8 The nozzle shall be held at such distance and position that the stream of flowing material will impinge at approximately right angles to the surface being covered. Any portions of the placed material which tend to sag or which show soft or sandy pockets or are otherwise unsatisfactory shall be cut out and replaced. Reinforcement thus damaged or destroyed shall be replaced by trimming back and properly lapping and tying, to the satisfaction of the ENGINEER.

511.6.9 Reinforcement shall be firmly supported in the position shown on the plans. Mortar blocks, metal chairs, clips, or spacers with wire ties or other acceptable means shall be used to properly anchor and place the reinforcement.

511.6.10 Where material is placed on overhead surfaces, the amount of water used shall be so adjusted that approximately 3/4 inch of the placed material shall adhere without support. The limit of thickness has been exceeded when the material begins to sag or slough.

511.7 FORMS AND GROUND WIRES

511.7.1 The forms shall be built in accordance with applicable provisions of the specifications, except all forms shall be built so as to permit the escape of air and rebound.

511.7.2 Ground wires shall be installed in such manner that they accurately outline the finished surface as indicated on the plans. They shall be located at intervals sufficient to insure proper thickness throughout. Wires shall be stretched tight and shall not be removed prior to application of the finished coat.

511.7.3 Headers will be required where the plans indicate a formed edge and at plan joints.

511.8 JOINTS

511.8.1 Construction joints shall be sloped off at an angle of approximately 45° to the surface being shot. Before shooting the adjacent sections, the sloped portion shall be thoroughly cleaned and wetted by means of air and water blast.

511.8.2 The plan joint shall be formed in accordance with and placed in the locations as designated on the plans.

511.9 FINISH

511.9.1 Upon reaching the thickness and shape outlined by forms and ground wire, the surface shall be rodded off to true lines.

511.9.2 Any low spots or depressions shall be brought up to proper grade by placing additional material. Ground wires shall then be removed; and unless otherwise specified, the surface shall then be broom finished to secure a uniform surface texture. Rodding and working with a wood float shall be held to a minimum.

511.9.3 Rebound or accumulated loose sand shall be thoroughly cleaned up and disposed of to the satisfaction of the ENGINEER. In no case shall it be floated into the surface of the work.

511.9.4 When a nozzle finish is specified on the plans, ground wires shall not be used and the surface shall be left as uniform as possible without rodding. Nozzle finishes will not be permitted where the underlay has been floated.

511.10 CURING

511.10.1 The pneumatically placed material shall be cured as prescribed for concrete curing, Section 105.

511.10.2 The CONTRACTOR shall at all times protect the finished work from being scarred or damaged in any way.

511.11 MEASUREMENT AND PAYMENT

Measurement for pneumatically placed concrete will be made in conformity with the terms of the Contract and will be based on units and/or quantities as set forth in the Bid Proposal. Such payment shall be full compensation for furnishing all labor, materials, tools, and equipment and doing all work required to complete the Work in conformity with the plans and specifications.

SECTION 512

PRECAST PRESTRESSED CONCRETE MEMBERS

512.1 GENERAL

This work shall consist of furnishing and placing precast prestressed concrete members in accordance with the details shown on the plans and as specified in these specifications and the Supplementary Specifications. This work shall include the manufacture, transportation, and storage of girders, slabs, and other structural members of precast prestressed concrete and shall also include the placing of all precast prestressed concrete members. The members shall be furnished complete including all concrete, prestressing steel, bar reinforcing steel, and incidental materials in connection therewith. Prestressing shall be performed by either pretensioning or post-tensioning methods. The method of prestressing to be used shall be optional with the CONTRACTOR, subject to the requirements specified in these specifications. Prior to casting any members to be prestressed, the CONTRACTOR shall submit to the ENGINEER for review complete details of the method, materials, and equipment he proposes to use in the prestressing operations, including any additions or rearrangement of reinforcing steel from that shown on the plans. Such details shall outline the method and sequence of stressing and shall include complete specifications and details of the prestressing steel and anchoring devices, anchoring stresses, type of enclosures, and all other data pertaining to the prestressing operation, including the proposed arrangement of the prestressing steel in the members, pressure grouting, materials, and equipment. For any rearrangement of stress force pattern, the stress calculations shall be submitted for approval by the ENGINEER.

512.2 REFERENCES

512.2.1 ASTM
A 416
A 421

512.2.2 This Publication:
SECTION 101
SECTION 510

512.3 CONCRETE

Concrete construction shall conform to the provisions in Section 510 of these specifications or as provided in the Supplementary Specifications. The design of the precast prestressed concrete members is based on the use of concrete having a minimum compressive strength or strengths at 28 days of not less than the values shown on the plans. The CONTRACTOR shall be responsible for furnishing concrete for prestressed members which contains not less than 6 sacks of cement per cubic yard of concrete, which is workable and which conforms to the strength requirements specified. Batch proportions shall be determined by the CONTRACTOR. The compressive strength of the concrete will be determined from concrete test cylinders cured under conditions similar to those affecting the member. The use of admixtures for the purpose of producing high strength at an early date shall be subject to the approval of the ENGINEER. In no case shall the admixture contain calcium chloride. Aggregate for use in the manufacture of concrete for prestressed members may be 1 inch maximum or 3/4 inch maximum, in lieu of 1 1/2 inch maximum, at the option of the CONTRACTOR. Concrete shall not be deposited in the forms until the ENGINEER has inspected the placing of the reinforcement, enclosures, anchorages, and prestressing steel. The concrete shall be vibrated internally or externally, or both, as required to consolidate the concrete. The vibrating shall be done with care and in such manner that displacement of reinforcement, enclosures, and prestressing steel will be avoided. Holes for anchor bars and for diaphragm dowels which pass through the member, openings for connection rods, recesses for grout, and holes for railing bolts shall be provided in the members in accordance with the details shown on the plans. Where diaphragm dowels do not pass through the member, the dowels may be anchored in the member by embedment in the concrete or by means of an approved threaded insert. Forms for interior cells or holes in the members shall be constructed of a material that will resist breakage or deformation during the placing of concrete and will not materially increase the weight of the member. Lifting anchors may be installed in members to be placed in bridge decks provided that all portions of the anchor above the concrete are removed after the members are placed. Side forms for prestressed members may be removed after a period of 24 hours, provided arrangements satisfactory to the ENGINEER are made for curing and protecting the concrete. However, side forms may be removed as soon as the transfer strength has been attained. The steam-curing method or other approved methods

may be used for curing precast prestressed concrete members in lieu of water curing. Steam curing, if elected by the CONTRACTOR, shall conform to the following provisions:

512.3.1 After placement of the concrete, members shall be held for a minimum 2-hour presteaming period. If the ambient air temperature is below 50°F, steam shall be applied during the presteaming period to hold the air surrounding the member at a temperature between 50°F and 90°F.

512.3.2 All exposed surfaces of the members shall be kept wet continuously during the holding and curing period.

512.3.3 The steam shall be saturated low pressure and shall be distributed uniformly over all exposed surfaces of the member but shall not directly impinge on the exposed concrete surfaces.

512.3.4 The steam hood shall be equipped with temperature recording devices that will furnish an accurate continuous permanent record of the temperatures under the hood during the curing period. The position of the temperature devices shall be approved by the ENGINEER.

512.3.5 During application of the steam, the temperature gradient within the enclosure shall not exceed 40°F per hour. The curing temperature shall not exceed 150°F and shall be maintained at a constant level for sufficient time necessary to develop the required compressive strength.

512.3.6 The members shall be protected from sudden temperature and moisture changes for at least 48 hours after completion of steam curing.

512.4 PRESTRESSING STEEL

512.4.1 Prestressing steel shall be high-tensile wire conforming to ASTM A 421, high-tensile wire strand conforming to the following requirements: the cross sectional steel area of wire strand shall be within 0.003 square inch of the nominal steel areas shown in Table I of ASTM A 416. In the event the CONTRACTOR elects to use a wire strand manufactured to a higher breaking strength than is specified in ASTM A 416, such higher strength strand shall, in addition, conform to the requirements of Table 512.4.1.

512.4.2 High-tensile strength alloy bars shall be thermal stress relieved to produce a suitable metallurgical structure and shall be individually proof tested during the process of manufacturing to a minimum of 90 percent of the manufacturer's minimum guaranteed ultimate strength. The mechanical properties of the completed bars shall be as per Table 512.4.2.

512.4.3 Bars of different ultimate strengths shall not be used interchangeably in the same member, unless otherwise permitted by the ENGINEER. In handling and shipping bars, every care shall be taken to avoid bending, injury from deflection, scraping, or overstressing of the bars. All damaged bars will be rejected. When bars are to be extended by the use of couplers, the assembled units shall have a tensile strength of not less than the specified minimum ultimate tensile strength. Failure of any one sample to meet this requirement will be cause for rejection of the heat of bars and lot of couplers. The location of couplers in the member shall be subject to approval by the ENGINEER. All wire or strand to be post-tensioned shall be:

512.4.3.1 Protected from corrosion during shipping by a factory treatment or processing.

512.4.3.2 Protected against abrasion during shipment and handling.

512.4.3.3 Installed in members after steam curing, when steam curing is used.

512.4.3.4 Grouted in the enclosures within 48 hours after the wire or strand has been tensioned.

512.4.4 Wires shall be straightened if necessary to produce equal stress in all wires of wire groups or parallel lay cables that are to be stressed simultaneously or when necessary to insure proper positioning in the enclosures. Where wires are to button-headed, the buttons shall be cold formed symmetrically about the axis of the wires and shall develop the full strength of the wire. No cold-forming process shall be used that causes indentations in the wire. When the button-headed wire assembly is tested as a unit in tension, at least 90 percent of the failures at or above the minimum guaranteed ultimate strength of the wire shall occur in the wire and not in the buttons. All prestressing steel shall be protected against rust and other corrosion and damage and shall be free of all dirt, scale, and pits due to rust, oil, grease,

TABLE 512.4.1

STRENGTH REQUIREMENTS

BREAKING STRENGTH REQUIREMENTS

Nominal Diameter (inches)	3/8	7/16	1/2
Breaking Strength (lbs.), min.	23,000	31,000	41,000
Nominal Steel Area (sq. in.)	0.058	0.116	.1531
Nominal Weight, 1000 ft., (lbs.)	292	400	525

YIELD STRENGTH REQUIREMENTS

Nominal Diameter (inches)	3/8	7/16	1/2
Initial Load (lbs.)	2,300	3,100	4,130
Maximum Load 1% Extension (lbs.)	19,600	26,400	35,100

TABLE 512.4.2

MECHANICAL PROPERTIES

	Regular Grade	Special Grade
Ultimate tensile strength psi, min.	145,000	160,000
Yield strength, measured by the 0-7 percent extension under load method, psi, min	130,000	140,000
Elongation in 20-bar diameters after rupture, percent, min.	4.0	4.0
Reduction of area, percent, min.		
Modulus of elasticity at 70 percent of the manufacturer's minimum guaranteed ultimate strength psi, min.	25×10^6	25×10^6

Diameter tolerances shall conform to ASTM A 29.

and other deleterious substances when finally encased in concrete or grouted in the member.

512.5 ANCHORAGES AND DISTRIBUTION

512.5.1 All post-tensioned prestressing steel shall be secured at the ends by means of approved anchoring devices. The anchors shall be of such nature that they will not kink, neckdown, or otherwise damage the prestressing steel. The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete. Anchoring devices for all post-tensioned prestressing steel shall be of the permanent type. Where the end of a post-tensioned assembly will not be covered by concrete, the anchoring devices shall be recessed so that the ends of the prestressing steel and all parts of the anchoring devices will be at least 2 inches inside of the end surface of the members, unless a greater embedment is shown on the plans. Following post-tensioning, the recesses shall be filled with grout and finished flush. When headed wires are used, the outside edge of any hole for prestressing wire through a stressing washer or through an unthreaded bearing ring or plate shall not be less than 1/4 inch from the root of the thread of the washer or from the edge of the ring or plate.

512.5.2 Distribution plates or assemblies shall conform to the following requirements:

512.5.2.1 The final unit compressive stress on the concrete directly underneath the plate or assembly shall not exceed 3,000 pounds per square inch, and suitable grillage of reinforcing steel shall be used in the stressed area.

512.5.2.2 Bending stresses in the plates or assemblies induced by the pull of the prestressing steel shall not exceed the yield point of the material or cause visible distortion, as determined by the ENGINEER, in the anchorage plate when 100 percent of the ultimate load is applied.

512.5.3 Should the CONTRACTOR elect to furnish anchoring devices of a type which are sufficiently large and which are used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stresses to the concrete, the steel distribution plates or assemblies may be omitted.

512.6 ENCLOSURES

Enclosures for prestressing steel shall be metallic and mortar-tight and shall be accurately placed at the locations shown on the plans or approved by the ENGINEER. In lieu of metallic enclosures, openings for prestressing steel may be formed by means of cores or ducts composed of rubber or other suitable material that can be removed prior to installing prestressing steel. All enclosures or openings or anchorage assemblies shall be provided with pipes or other suitable connections for the injection of grout after prestressing.

512.7 PRESTRESSING

512.7.1 All prestressing steel shall be tensioned by means of hydraulic jacks. Each jack shall be equipped with a pressure gauge having an accurately reading dial at least 6 inches in diameter and each jack and its gauge shall be accompanied by a certified calibration chart showing the relationship between gauge readings and stress in the ram for both ascending and descending movements of the ram.

512.7.2 The tensioning of prestressing steel in any post-tensioned member and the cutting or releasing of prestressing steel in any pretensioned member shall not be performed until tests on concrete cylinders indicate that the concrete in the member has attained a compressive strength of not less than the value shown on the plans.

512.7.3 Subject to prior approval by the ENGINEER, a portion of the total prestressing force may be applied to a member when the strength of the concrete in the member is less that the value shown on the plans and the member may then be moved. Approval by the ENGINEER of such partial prestressing and moving shall in no way relieve the CONTRACTOR of full responsibility for successfully constructing the members.

512.7.4 The cutting and releasing of prestressing steel in pretensioned members shall be performed in such an order that lateral eccentricity of prestress will be a minimum. The prestressing steel shall be cut off flush with the end of the member and the exposed ends of the prestressing steel shall be heavily coated with roofing asphalt or coal tar.

512.7.5 Post-tensioning will not be permitted until it is demonstrated to the satisfaction of the ENGINEER that the prestressing steel is free and unbonded in the enclosure.

512.7.6 The tensioning process as applied to post-tensioned members shall be so conducted that tension being applied and the elongation of the prestressing steel may be measured at all times. A record shall be kept of gauge pressures and elongations at all times and shall be submitted to the ENGINEER for approval.

512.7.7 Prestressing steel in post-tensioned members shall be tensioned by simultaneous jacking at each end of the assembly, except as provided by the following:

512.7.8 Jacking from one end of the assembly will be permitted on simple span members under 65 feet in length, provided the calculations show that the maximum temporary tensile stress at the center of the span will not be more than 70 percent of the ultimate tensile strength of the prestressing steel.

512.7.9 For simple span members 65 feet and over in length, jacking from one end will be permitted, provided the calculations and also field tests demonstrate that the maximum stresses at the center of the span will not be more than 70 percent of the ultimate tensile strength of the prestressing steel.

512.7.10 Unless otherwise permitted by the ENGINEER, half of the prestressing steel in each member shall be stressed from one end of the span and the other half from the opposite end. Determination of the jacking stresses shall be supported by calculations or both calculations and field tests when specified, prepared by the CONTRACTOR. The CONTRACTOR shall submit his calculations to the ENGINEER for approval and prior to making field tests, shall submit details of his proposed gauges and load devices for determining the jacking load at each end of the test prestressing unit to the ENGINEER for approval. The stress at the center will be calculated from the average of the end test loads. Jacking stresses within 2 percent of the specified values will be considered satisfactory.

512.7.11 The friction coefficients on Table 512.7.11 shall be used in calculating friction losses. K represents the wobble of the ducts, and U represents the curvature in draped cables.

512.7.12 The maximum temporary tensile stress (jacking stress) in prestressing steel shall not exceed 75 percent of the ultimate tensile strength of the prestressing steel. The prestressing steel shall be anchored at stresses (initial stress) that will result in the ultimate retention of working forces of not less than those shown on the plans but in no case shall the initial stress exceed 70 percent of the ultimate tensile strength of the prestressing steel.

512.8 BONDING AND GROUTING

Post-tensioned prestressing steel shall be bonded to the concrete by pressure grouting and enclosures or openings. All prestressing steel to be bonded to the concrete shall be free of scale and pits due to rust, dirt, oil, grease, and other deleterious substances. Grouting equipment shall be capable of grouting to a pressure of at least 100 pounds per square inch. The grouting shall consist of neat cement and water conforming to the provisions in Section 101, Portland Cement Concrete. The grout shall completely fill the enclosure or opening. All enclosures or openings shall be clean and free of all foreign materials that would impair bonding of the grout. Each enclosure or opening shall be thoroughly flushed out with water and blown out with air or cleaned by other approved methods immediately prior to grouting. After post-tensioned prestressing steel has been pressure grouted, the member shall not be moved or otherwise disturbed until at least 24 hours have elapsed.

512.9 SAMPLES FOR TESTING

512.9.1 Sampling and testing shall conform to the specifications of ASTM A 416 and ASTM A 421 and as specified in this section. Samples from each size and each lot of prestressing steel wires and bars, from each manufactured reel of prestressing steel strand, and from each lot of anchorage assemblies and bar couplers to be used shall be furnished for testing. All materials for testing shall be furnished by the CONTRACTOR at his expense. The CONTRACTOR shall have no claim for additional compensation in the event his work is delayed awaiting approval of the materials furnished for testing. All wire or bars of each size from each mill lot and all strand from each manufactured reel to be shipped to the site shall be assigned an individual lot number and shall be tagged in such a manner that each such lot can be accurately identified at the job site. Each lot of anchorage assemblies and bar couplers to be installed in the site shall be like-

TABLE 512.7.11

FRICTION COEFFICIENTS

Type of Steel	Type of Duct	K	U
Bright metal wire or strand	Bright metal	0.002	0.30
	Galvanized	0.0015	0.25
Bright metal bars	Bright metal	0.0003	0.20
	Galvanized	0.0002	0.15

wise identified. All unidentified prestressing steel, anchorage assemblies, or bar couplers received at the site will be rejected. The following samples of material and tendons, selected by the ENGINEER from the prestressing steel at the plant or job site, shall be furnished by the CONTRACTOR to the ENGINEER well in advance of anticipated use:

512.9.1.1 For wire or strand, one 7 foot long sample shall be furnished for each heat or reel; and for bars, one 6 foot long sample shall be furnished for each heat.

512.9.1.2 If the prestressing tendon is to be prefabricated, one completely fabricated prestressing tendon 5 feet in length for each size of tendon shall be furnished, including anchorage assemblies. If the prestressing tendon is to be assembled at the job site, sufficient wire or strand and end fittings to make up one complete prestressing tendon 5 feet in length for each size of tendon shall be furnished, including anchorage assemblies.

512.9.1.3 If the prestressing tendon is a bar, one 6 foot length complete with one end anchorage shall be furnished; and in addition, if couplers are to be used with the bars, two 3 foot lengths of bar equipped with one coupler and fabricated to fit the coupler shall be furnished.

512.9.2 Prestressing systems previously tested and approved need not be furnished as complete tendon samples, provided there is no change whatsoever in the material, design, or details previously approved. Shop drawings shall contain an identification of the project on which approval was obtained, otherwise sampling will be necessary. For prefabricated tendons, the CONTRACTOR shall give the ENGINEER at least 10 days notice before commencing the installation of end fittings or the heading of wires. The ENGINEER may inspect all end fitting installations and wire headings while such fabrication is in progress at the plant and will arrange for all required testing of the material to be shipped to the site. No prefabrication tendon shall be shipped to the site without first having been released by the ENGINEER, and each tendon shall be tagged before shipment for identification purposes at the site. All unidentified tendons received at the site will be rejected. Job site or site as referred to herein shall be considered to mean the location where the members are to be manufactured, whether at the project site or a removed casting yard.

The release of any material by the ENGINEER shall not preclude subsequent rejection if the material is damaged in transit or later damaged or found to be defective.

512.10 HANDLING

Extreme care shall be exercised in handling, storing, moving, and erecting precast prestressed concrete members to avoid twisting, racking, or other distortion that would result in cracking or damage to the members. Precast prestressed members shall be handled, transported, and erected in an upright position; and the points of support and directions of the reactions with respect to the member shall be approximately the same during transportation and storage as when the member is in its final position. Precast prestressed concrete members shall be placed in the structure in conformity with the plans and Supplementary Specifications. Precast prestressed concrete piling shall be placed in accordance with the provisions for concrete piling.

512.11 MEASUREMENT AND PAYMENT

Precast prestressed concrete members will be measured using the unit quantities for furnishing precast prestressed concrete members of the various types and lengths as outlined in the Bid Proposal or quantities for erecting the members as shown in the Bid Proposal. When various lengths or types of members are grouped together for measurement, the basis of grouping will be shown on the Bid Proposal. This measurement shall include furnishing all labor, materials, tools, equipment, and incidentals for completing all work involved and ready for erection, as shown on the plans and as provided in these specifications, the Supplementary Specifications, or as directed by the ENGINEER. Measurement also includes furnishing and placing transverse connections, anchor rods, lifting eyes, expansion joint material, as well as grouting spaces and recesses between the members.

SECTION 520

STEEL STRUCTURES

520.1 GENERAL

This work shall consist of furnishing, erecting, and painting structural steel members and elements of structural steel, steel forgings, steel castings, gray iron castings, malleable castings, wrought iron, bronze castings, rolled copper alloy, and other ferrous or nonferrous materials in substantial compliance with the specifications, dimensions, shapes, and design shown on the plans for steel structures and for concrete structures where structural steel is indicated, according to latest AISC specifications.

520.2. REFERENCES

520.2.1 ASTM
A 36
A 47
E 350

520.2.2 AASHTO
M 102 M 108
M 103 M 183
M 105 M 228
M 107

520.2.3 This Publication:
SECTION 139
SECTION 157

520.2.4 Others:
Specifications for Welded Highway and Railroad Bridges, American Welding Society

520.3 MATERIALS

Applicable materials specifications are as follows:

520.3.1 Structural steel shall conform with the requirements of AASHTO M 183 (ASTM A 36), unless otherwise specified.

520.3.2 Rivet steel shall conform with the requirements of AASHTO M 228.

520.3.3 Steel forgings shall conform with the requirements of AASHTO M 102, Class C 1.

520.3.4 Steel castings shall conform with the requirements of AASHTO M 103, Grade 65-35.

520.3.5 Gray iron castings shall conform with the requirements of AASHTO M 105, Class 30.

520.3.6 Malleable castings shall conform with the requirements of ASTM A 47. Malleable castings shall be boldly filleted at angles and the arises shall be sharp and perfect.

520.3.7 Wrought iron plates, bars, and shapes shall conform with the requirements of ASTM E 350.

520.3.8 Cast bronze plates shall conform with the requirements of AASHTO M 107, Alloy B.

520.3.9 Rolled copper alloy plates shall conform with the requirements of AASHTO M 108, Alloy No. 1.

520.3.10 Sheet lead shall be of good commercial quality.

520.3.11 Aluminum and aluminum alloy materials shall conform with the ASTM or Aluminum Alloy Designation shown on the plans.

520.3.12 Paint shall conform with applicable requirements of Section 157, Paint. All steel members shall be painted with one coat of red lead and two coats of aluminum paint, unless otherwise specified.

520.4 CONSTRUCTION REQUIREMENTS

520.4.1 Structural material, either plain or fabricated, shall be stored at the bridge shop above the ground on platforms, skids, or other supports. It shall be kept free from dirt, grease, and other foreign matter and shall be protected from corrosion. These requirements shall apply to fabricated material stored prior to shipment, as well as to the unfabricated material stored at the shop.

520.4.2 Rolled material, before being laid off or worked, shall be straight. When straightening is required, it shall be done by methods that will not produce fractures or otherwise injure the metal. The metal shall not be heated unless permitted by the ENGINEER. The heating shall not be a higher temperature than that producing a dark cherry red color. After heating, the metal shall be cooled slowly. Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture. Sharp kinks and bends shall

be cause for rejection of the material. Finished members shall be true to line and free from twists, bends, and other deformities.

520.4.3 Workmanship and finish shall conform with current standard shop practices. Shearing, flame cutting, and chipping shall be done carefully and accurately. Sheared edges of plates more than 5/8 inch in thickness and carrying calculated stress shall be planed for a depth of 1/4 inch. Re-entrant cuts shall be filleted before cutting.

520.4.4 Steel or wrought iron may be flame cut, provided a smooth surface is obtained. Flame cutting by hand shall be done only when approved by the ENGINEER, and the surface of such cuts shall be made smooth by planing, chipping, or grinding.

520.4.5 Shop inspection of structural steel does not relieve the CONTRACTOR of responsibility for fabrication errors. Errors discovered in the field shall be corrected by the CONTRACTOR without expense to the OWNER.

520.4.6 The inspector shall furnish 8 copies of a shop inspection report covering fabrication and inspection of all structural steel items, including a report on the interpretation of the radiographs when applicable.

520.5 WELDING

520.5.1 General Welding of steel shall be confined to such details as shown on the plans or authorized by the ENGINEER and shall conform to the specifications for Welded Highway and Railway Bridges of the American Welding Society. Shop shall remove all slag from shop welds before shipment.

520.5.2 Welded Steel Girders: Where welding is called for on the plans, welds may be made by an automatic or semi-automatic submerged arc in a deposit of granular or powdered flux using direct current or may be manually welded with shielded metal arc electrodes conforming to American Welding Society Specifications except that E6012, E6013, E6020, E7014, and E7024 electrodes shall not be used.

520.5.3 The fabricator will be required to demonstrate the capability of the electrodes, flux, and procedures he proposes to use for submerged arc welding.

520.5.4 All tension flange butt welds shall be radiographed for the entire length of the joints. Tne tension area of all web plate butt welds shall be radiographed. If defects found in the above welds indicate the desirability, enough of the compression flange butt welds shall be radiographed to satisfy the ENGINEER of their acceptability.

520.5.5 At the option of the ENGINEER, fillet welds shall be examined by magnetic particle or penetrant dye techniques. One foot in each 10 feet of such welds may be examined; and if defects found indicate the desirability, additional examinations shall be made.

520.5.6 Tne radiographs, penetrant dye, or magnetic particle inspections shall be made by a qualified operator approved by the ENGINEER using approved equipment in accordance with Appendix E of A.W.S. Specifications for Welded Highway and Railway Bridges. Tne quality of the welds shall be acceptable under Paragrapn 409 and Appendix F of these A.W.S. Specifications.

520.5.7 Defects in welds as shown by the inspections shall be removed by chipping or grinding to sound metal and the resulting cavities shall be rewelded. Welds tnat have been repaired shall oe re-examined by methods initially used to reveal the defects.

520.5.8 All butt welds in flange plates shall be ground smooth with adjacent plates. Tne entire transition adjacent to butt welds between plates of different width or different thickness shall be ground smooth with adjacent plates, witn grinding being done in direction of the stress. This grinding to produce a smootn transition without any trace of undercut or overlap of the weld. Care must be exercised to prevent grinding a depression in the thinner plate for the narrower plate at the junction. If this occurs, the depression must be filled with weld metal and the transition ground smooth.

520.5.9 The CONTRACTOR shall provide all equipment apparatus, supplies, and labor required for making the radiographic tests and magnetic particle or penetrant dye examinations and the cost tnereof shall be included in the contract unit price per pound for structural steel. The CONTRACTOR shall turn over the radiograph films to the ENGINEER for interpretation.

520.5.10 The CONTRACTOR shall furnish a certified copy of test reports of all pertinent required tests under the

American Welding Society Specifications made on electrodes of the same class, size, and brand and which were manufactured by the same process and with the same materials as the electrodes furnished. The tests may have been for process qualifications or quality control and shall have been made within one year prior to manufacture of the electrodes furnished. The CONTRACTOR shall furnish 8 copies of the manufacturer's certification that the process and material requirements were the same for manufacturing the tested electrodes and the furnished electrodes.

520.6 JOINTS AND CONNECTIONS

520.6.1 When plans require abutting joints to be milled, the ends of the abutting members shall be accurately faced to provide a full and even bearing when assembled in the structure. When the plans require close joints, the opening between ends of abutting tension members shall not exceed 1/8 inch and the opening between abutting ends of rolled girders at splices shall not exceed 1/4 inch.

520.6.2 End connection angles of floor beams and stringers shall be flush with each other and accurately set to position and length of member. End connection angles shall not be finished unless shown on plans and the finished thickness shall not be less than the thickness shown on the plans. When finishing is authorized by the ENGINEER to remedy faulty assembling and riveting, the thickness shall not be reduced more than 1/16 inch nor shall the rivet bearing value be reduced below design requirements.

520.7 RIVETED PLATE GIRDERS

520.7.1 Plate girders having no cover plates and not to be encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles and shall not be more than 1/8 inch below at any point. Any portion of the plate projecting beyond the angles shall be chipped flush with the backs of the angles. Web plates in girders having cover plates may be 1/2 inch less in width than the distance back to back of flange angles. Splices in webs of girders without cover plates shall be sealed on the top edge with red lead paste prior to painting. At web splices, the clearance between the ends of the web plates shall not exceed 3/8 inch. The clearance at the top and bottom ends of web splice plates shall not exceed 1/4 inch.

520.7.2 End stiffeners of plate girders or rolled beams and intermediate stiffeners for concentrated loads shall be milled or ground to obtain an even bearing against the flange angles or rolled flange. Intermediate stiffeners shall fit sufficiently tight against bottom flanges to exclude water after being painted. Fillers under stiffeners shall fit within 1/4 inch at each end. Flanges of rolled beams, against which stiffeners are to be made to bear, and at splices shall be straightened perpendicular to the web at the location of the stiffener before stiffeners are fitted and at the spliced end before shipment.

520.8 HOLES FOR RIVETS AND BOLTS

520.8.1 All holes shall be either punched or drilled. Shop connections for forming parts of a member composed of not more than 5 thicknesses of metal may be punched 1/16 inch larger than the nominal diameter of the connector whenever the thickness of the metal is not greater than 3/4 inch for strucural steel or 5/8 inch for alloy steel. When there are more than 5 thicknesses or when any of the main material is thicker than 3/4 inch in carbon steel, or 5/8 inch in alloy steel, or when required for field connections, all the holes shall be subpunched or subdrilled 3/16 inch smaller and, after assembling, reamed 1/16 inch larger or drilled from the solid to 1/16 inch larger than the nominal diameter of the connector. All holes in material which is thicker than the nominal diameter of the connectors shall be subdrilled and reamed or drilled from the solid after assembling. The diameter of the die shall not exceed the diameter of the punch by more than 1/16 inch. When holes are enlarged to admit the connectors, they shall be reamed. Holes must be clean cut, without torn or ragged edges. Poor matching of holes will be cause for rejection.

520.8.2 Reamed holes shall be cylindrical, perpendicular to the member, and not more than 1/16 inch larger than the nominal diameter of the connector. Drilled holes shall be 1/16 inch larger than the nominal diameter of the connector. Burrs on the outside surfaces shall be removed. Poor matching of holes will be cause for rejection. Reaming and drilling shall be done with twist drills. Assembled parts shall be taken apart for removal of burrs caused by drilling or reaming. Connecting parts requiring reamed or drilled holes shall be assembled and securely held while being

reamed or drilled and shall be match-marked before disassembling. The use of tack welding in the shop of riveted beam and girder cover plates or bolted field splice materials for the purpose of drilling or reaming the holes will not be permitted.

520.8.3 Unless otherwise provided, holes in all field connections and field splices of main truss or arch members, continuous beams, plate girders, and rigid frames shall be subpunched or subdrilled and reamed either assembled or through a steel template not less than 1 inch thick or drilled full size either assembled or through a steel template not less than 1 inch thick. Other satisfactory methods approved by the ENGINEER may be used. The assembly, including alignment, camber, accuracy of holes, and milled joints shall be carefully checked before reaming is begun. Unless otherwise authorized by the ENGINEER, each individual truss, arch, continuous beam, plate girder, or rigid frame shall be assembled in the shop before reaming is commenced.

520.8.4 All holes for floor beams and stringer field connections and other connections shown on the plans shall be subpunched or subdrilled and reamed or drilled full size to a steel template not less than 1 inch thick or reamed or drilled full size while assembled. Other satisfactory methods approved by the ENGINEER may be used.

520.8.5 All holes punched or drilled full size shall be so accurately punched or drilled that when assembled and before any reaming is done a cylindrical pin 1/8 inch smaller in diameter than the nominal size of the hole may be entered perpendicular to the face of the member without drifting in not less than 75 percent of the contiguous holes in the same plane. The remaining holes may be reamed not to exceed 1/32 inch to pass the cylindrical pin. Connections not meeting the requirements herein provided may be rejected. The accuracy of subdrilled holes shall be the same as required for punched holes. When holes are reamed, drilled, or assembled, 85 percent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 inch between adjacent thickness of metal.

520.9 FABRICATION

520.9.1 Surface of metal in contact shall be cleaned before assembling. The parts of a member shall be assembled, well pinned, and firmly drawn together with bolts before reaming, riveting, or bolting is begun. Tack welding will not be permitted. Assembled pieces shall be taken apart when required for the removal of burrs and shavings produced by the reaming or drilling operation. The member shall be free from twists, bends, and other deformation.

520.9.2 End connection angles, stiffener angles, beam and girder cover plates, and similar parts shall be carefully adjusted to correct positions and bolted, clamped, or otherwise firmly held in place until connected. Tack welding will not be permitted, except on welded cover plates.

520.9.3 Parts not completely connected in the shop shall be secured by bolts to prevent damage in shipment and handling.

520.9.4 Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be matchmarked, and a diagram showing such marks shall be shown on the shop drawings.

520.9.5 The size of rivets shown on the plans shall be the size before heating. Rivet heads shall be of standard shape, unless otherwise provided, and of uniform size for the same diameter of rivet. Rivet heads shall be full, concentric with the shank and in full contact with the surface of the member.

520.9.6 Rivets shall be heated uniformly to a light cherry red color and shall be driven while hot, completely filling the holes. Rivet points that are heated more than the remainder of the rivet shall not be driven. When a rivet is ready for driving, it shall be free from slag, scale, or other adhering matter. Any rivet which is scaled excessively will be rejected. Rivets which throw off sparks when taken from the forge shall not be driven. All rivets that are burned, loose, badly formed, or otherwise defective shall be removed and replaced. Any rivet head that is deficient in size or is driven off center shall be removed. Stitch rivets that are loosened by the driving of adjacent rivets shall be removed and replaced. In cutting out defective rivets, care shall be taken not to injure the adjacent metal; and when required, the rivet shanks shall be removed by drilling, the use of a cutting torch will not be permitted. Caulking or recupping of rivet heads will not be permitted. Approved beveled rivet sets shall be used for forming rivet heads on sloping surfaces. Counter-sinking shall be neatly done, and counter-sinking rivets shall completely fill the holes.

520.9.7 Bolted connections shall be used when shown on the plans or authorized by the ENGINEER for connections where it is impracticable to drive rivets. Where bolted connections are required, the bolts used shall be of the type shown on the plans or designated by the ENGINEER. High tensile strength bolts shall conform to the provisions of Section 139.

520.9.8 Turned bolts shall conform to details shown on the plans. The bolt shank shall be 1/16 inch larger than the nominal bolt size, shall be turned to a driving fit, and finished with a finishing cut. The threaded end shall be the nominal bolt size and shall terminate against the shank with a square shoulder entirely outside the hole. The bolts shall be of such length that threads will be entirely outside the hole and will extend entirely through the nuts not more than 1/4 inch. Heads and nuts shall be hexagonal. One-fourth inch nut locks shall be used on all turned bolts.

520.9.9 Ribbed bolts shall have a drive fit. The ribbed shank shall be slightly larger than the nominal bolt diameter with triangular longitudinal ribs. The ribbed shank shall extend entirely outside of the hole. The threaded end shall be the nominal bolt size and shall terminate against the shank with a square shoulder. Heads may be button heads, and nuts shall be hexagonal and recessed on the inside face to receive the shank and permit tightening securely against the connected parts. Ribbed bolts shall be of such length that threads will extend through the nuts not more than 1/4 inch. Self-locking nuts or 1/4 inch nut locks will be required on all bolts.

520.9.10 Unfinished bolts shall be standard bolts with square or hexagonal heads and hexagonal nuts. Bolts shall be threaded to such a length that not more than one thread will be within the grip of the connected parts and bolts shall be of the length that threads will extend through the nut not more than 1/4 inch. One-fourth inch nut locks shall be used on all bolts.

520.9.11 Turned and ribbed bolts shall be driven accurately into the holes without damaging the threads. The heads and nuts shall be drawn tight against the connected parts with a suitable wrench. Heads of drive fit bolts shall be tapped with a hammer while the nut is being tightened. Where bolts are used in beveled surfaces, beveled washers shall be provided to give full bearing to the head or nut.

520.10 BASE AND CAP PLATES--PINS AND ROLLERS

520.10.1 Ends of columns taking bearing upon base and cap plates shall be milled to true surfaces and correct bevels after the main section of these members and the end connection angles have been fully connected.

520.10.2 Cap and base plates of columns and the sole plates of girders and trusses shall have full contact when assembled. The plates, if warped or deformed, shall be hot-straightened, planed, or otherwise treated to secure an accurate, uniform contact. After being riveted in place, the excess material of countersunk rivet heads shall be chipped smooth and flush with the surrounding metal and the surfaces which are to come in contact with other metal surfaces shall be planed or milled, when required, to secure proper contact. The surfaces of base and sole plates that are to come in contact with masonry shall be rough-finished or not-straightened when not free from warps or other deficiencies.

520.10.3 When planing the surfaces of expansion plates, the cut of the tool shall be in the direction of expansion. Surfaces of cast bronze bearing plates for sliding contact shall be carefully milled and polish finished. Finishing of rolled copper alloy plates will not be required provided they have a plane with a smooth surface. Surfaces of pedestals and shoes which come in contact with metal surfaces shall be planed and those which are to take bearing upon the masonry shall be rough-finished.

502.10.4 Pins and rollers shall be accurately turned to dimensions and shall be smooth, straight, and free from flaws. Pins and rollers more than 9 inches in diameter shall be forged and annealed. Pins larger than 9 inches in diameter shall have a hole not less than 2 inches in diameter bored longitudinally through the centers. Pins showing defects will be rejected.

520.10.5 Pin holes shall be bored to dimensions, smooth and straight, at right angles with the axis of the member and parallel, unless otherwise required. The diameter of the pin hole shall not exceed that of the pin by more than 1/16 inch for pins 5 inches or less in diameter or 1/32 inch for larger pins. Boring of holes in built up members shall be done after the assembly is completed.

520.10.6 Threads for pins shall conform to the American National Coarse Thread Series, Class 2, free fit, except that the pin ends having a diameter of 1 3/8 inches or more shall be threaded 6 threads to the inch.

520.11 PRE-ERECTION REQUIREMENTS

520.11.1 Each member shall be painted or marked with an erection mark for identification and an erection diagram shall be furnished with erection marks shown thereon. The CONTRACTOR shall furnish as many copies of material orders, shipping statements, and erection diagrams as the ENGINEER may direct. The weights of the individual members shall be shown on the statements. Members weighing more than 3 tons shall have the weights marked thereon. Structural members shall be loaded on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed, or otherwise damaged. Bolts and rivets of one length and diameter and loose nuts and washers of each size shall be packed separately. Pins, small parts, and packages of rivets, bolts, washers, and nuts shall be shipped in boxes, crates, kegs, or barrels. The gross weight of any package shall not exceed 300 pounds. A list and description of the material shall be plainly marked on the outside of each shipping container. When steel is painted in the shop, field rivet heads, field bolt heads and nuts, and abrasions in the original shop coat, due to handling during shipping and erecting, shall be covered with shop paint after the steel is erected.

520.11.2 The CONTRACTOR shall give ample notice to the ENGINEER of the beginning of work, at shop, so that inspection may be provided. No material shall be fabricated before the ENGINEER has been notified. Shop inspection may be waived by the ENGINEER.

520.11.3 The CONTRACTOR shall submit to the ENGINEER five complete sets of blueprints of shop and erection drawings for preliminary approval. One approved set will be returned to the CONTRACTOR with notations. The CONTRACTOR shall then furnish the ENGINEER with 10 sets of the final shop drawings for approval and no fabrication shall be done before approval has been given. No changes shall be made on any drawing without the approval of the ENGINEER. The CONTRACTOR shall furnish the ENGINEER with eight copies of mill test reports covering all structural steel items, including railing.

520.11.4 Structural material, either plain or fabricated, shall be stored above the ground on platforms, skids, or other supports. Such material shall be kept free from dirt, grease, and other foreign matter and properly drained and protected as far as practicable from corrosion. Girders and beams shall be placed upright and shored. Long members shall be supported on skids placed near enough together to prevent injury from deflection.

520.12 ERECTION REQUIREMENTS

520.12.1 Falsework shall be properly designed and substantially constructed and maintained for the required loads. When required, the CONTRACTOR shall prepare and submit to the ENGINEER for approval plans for falsework. Approval of the CONTRACTOR's falsework plans shall not relieve the CONTRACTOR of his responsibility. Falsework which cannot be founded on a footing shall be supported on falsework piling.

520.12.2 All work of erection shall be subject to the inspection of the ENGINEER, who shall be given all facilities required for a thorough inspection of workmanship. Before starting the work of erection, the CONTRACTOR shall inform the ENGINEER as to the method of erection he proposes to follow and the amount and character of equipment he proposes to use, which shall be subject to the approval of the ENGINEER. The approval of the ENGINEER shall not relieve the CONTRACTOR of his responsibility for the safety of his method or equipment or from carrying out the work as herein provided.

520.12.3 Column bases, truss and girder pedestals and shoes, and other masonry bearings shall have a full and uniform bearing upon the substructure masonry. Such bearings shall not be placed on the bridge seat areas of piers or abutments that are improperly finished or irregular.

520.12.4 The shoes and pedestals of truss and girder spans, the bases of columns, and other masonry bearings shall be located to correct alignments and elevations. Unless otherwise provided, shoes and pedestals of truss and girder spans shall be placed on lead sheets of the thickness shown on the plans.

520.12.5 Anchor bolt holes shall be installed at locations and in manner shown on the plans, perpendicular to the plane of the bridge seat. Unless otherwise shown on the plans or authorized by the ENGINEER, anchor bolts placed in

drilled holes shall be set in Portland cement mortar. The mortar shall consist of 1 part cement to 1 part clean,fine grained sand mixed with a minimum of water necessary to set the anchor bolts. Anchor bolts shall be placed in the dry holes to assure satisfactory fit after setting. The bolts shall be set as herein provided. The holes shall be partially filled with mortar so that by uniform even pressure or light blows with a hammer the bolts will be forced into the holes and the mortar will rise to the top of the holes. All excess mortar shall be removed after the bolts have been set. The anchor bolt nut shall rest firmly against the metal shoe or pedestal. Anchor bolts at the expansion ends of spans shall permit the free movement of the span.

520.12.6 Field assembling of the component parts of a structure shall be consistent with standard construction practices to prevent injury to the metal. Members bent or twisted shall be corrected or removed and replaced without expense to the OWNER.

520.12.7 Unless erected by the cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber. The blocking shall be left in place until the tension cord splices are fully connected and all other truss connections pinned or bolted. Rivets or bolts, in splices of butt joints of compression members and in railings, shall not be placed until the span has been swung.

520.12.8 Riveted or bolted field splices and joints for assembling steel members shall be made up with erection bolts and cylindrical erection pins. A sufficient number of erection pins shall be used to align the holes and a sufficient number of bolts shall be used to bring and hold the component parts of the splice or joint in full contact. In assembling and making up splices and connections for main truss and arch members at least 1/2 of the holes shall be filled with pins and bolts. All splices and connections carrying traffic during erection shall be made up with pins and bolts in at least 3/4 of the holes.

520.12.9 Erection bolts shall be of the same nominal diameter as the rivets or field bolts. Cylindrical erection pins shall be 1/32 inch larger than the nominal diameter of the rivets or bolts. High tensile strength steel bolts may be used as erection bolts, provided they are not loosened and retightened.

520.12.10 The straightening of bent edges of plates, angles, and other shapes shall be done by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted by the ENGINEER, in which case the heating shall not be to a higher temperature than that producing a dark cherry red color. After heating, the metal shall be cooled as slowly as possible. Following the completion of the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of incipient or other fractures.

520.12.11 The results obtained in the field assembling and riveting of the members of a structure shall conform to the requirements for shop assembling and riveting. Field-driven rivets shall be inspected and accepted before being painted. Field riveting or bolting shall be done before the falsework is removed, except for compression chords of trusses, unless special permission to the contrary is given by the ENGINEER. Railings shall not be fastened until the falsework has been removed and all dead load is in place on the span and shall be adjusted to bring the railing to exact line and grade.

520.12.12 Pneumatic hammers shall be used for field riveting. Cup faced dollies, fitting the head closely to insure good bearing, shall be used. Connections shall be accurately and securely fitted up before the rivets are driven. Drifting shall be only such as to draw the parts into position and not sufficient to enlarge the holes or distort the metal. Unfair holes shall be reamed or drilled if permitted by the ENGINEER. Rivets shall be heated uniformly to a light cherry red color and shall be driven while hot. They shall not be overheated or burned. Rivet heads shall be full and symmetrical, concentric with the shank, and shall have full bearing all around. They shall not be smaller than the heads on the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. Caulking or recupping will not be permitted. In removing rivets, the surrounding metal shall not be injured; if necessary, they shall be drilled out. No rivets shall be removed by flame cutting.

520.12.13 Unless otherwise required, bolted splices and field connections shall be fitted up as required for riveted connections with drift pins and fitting-up bolts.

520.12.14 Pilot and driving nuts shall be used in driving pins, details shall be shown on the shop plans. One pilot and one driving nut for each size pin shall be furnished by the CONTRACTOR without charge. Pins shall be driven so that the members will take full bearing on them.

520.12.15 The correction of minor misfits involving unharmful amounts of reaming, cutting, and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformations resulting from handling and transportation which prevent the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the ENGINEER and his approval of the method of correction obtained. The correction shall be made in his presence.

520.12.16 Before concrete floor are placed on steel truss or arch spans, the centering under the bridge shall be released and the span swung free on its supports. The operation of placing the concrete in any floor slab shall be continuous between expansion joints, unless otherwise provided on the drawings.

520.13 MEASUREMENT AND PAYMENT

520.13.1 Structural steel and other metal material will be measured by the computed weight, in pounds, based on the details shown on the fabricator's approved shop drawings or from detailed plans prepared by the ENGINEER when shop drawings are not required. Payment will be made at the unit price per pound in accordance with the Bid Proposal. When provided in the the Bid Proposal, structural steel and other metals may be measured and paid for on a lump sum basis.

520.13.2 The CONTRACTOR will be paid only for the material actually installed in the completed structure.

520.13.3 Should the CONTRACTOR, upon his request in writing, be allowed to substitute heavier sections than are called for on the design drawings, the additional weight of such heavier sections will not be paid for.

520.13.4 The ENGINEER may require the CONTRACTOR to furnish scale weights of the metal members. If the scale weight of any member is less than 97.5 percent of the computed weight, it shall be cause for rejection.

520.13.5 The computed weight will be determined as follows:

520.13.5.1 The weight of steel shall be assumed at .2833 pounds per cubic inch. The weight of cast iron shall be assumed at .2575 pounds per cubic inch. The weight of bronze shall be assumed at .3102 pounds per cubic inch. The weight of lead shall be assumed at .4091 pounds per cubic inch.

520.13.5.2 The weight of rolled shapes and plates shall be computed on the basis of their nominal weights and dimensions, as shown on the approved shop drawings, deducting for copes, cuts, and open holes, except that open holes for rivets shall not be deducted.

520.13.5.3 The weight of heads of rivets and bolt elements outside the grip, in place in the finished structure, shall be included in the computed weight.

520.13.5.4 The weight of castings shall be computed according to the net volume of the finished casting as shown on the approved shop drawings, with an addition of 10 percent for fillets and overrun.

520.13.5.5 The weight of weld metal shall not be included in the computed steel weight.

SECTION 530

TIMBER STRUCTURES AND TIMBER CONSTRUCTION

530.1 GENERAL

Timber structures erected under these specifications shall conform to the dimensions and details shown on the plans and shall be constructed in accordance with these requirements unless otherwise provided.

530.2 REFERENCES

530.2.1 This Publication:
SECTION 146
SECTION 157

530.3 MATERIALS

Timber and lumber that is stored prior to its use shall be neatly piled on skids in a manner that will prevent warping and shall be protected from the sun when so required. Materials shall be stored or piled to permit ready access for inspection. The use of cant hooks, peavies, or other pointed tools and hooks will not be permitted in the handling of structural timber, lumber or piles. Care and precaution shall be exercised in handling treated material in order not to damage or abrade the surface thereof to the extent of exposing untreated wood, and any piece so damaged or abraded will be rejected. Treated timber or piling cut after treatment shall be treated in accordance with Section 146. This same requirement shall apply to any surface that has become damaged or abraded to the extent of exposing untreated wood. All borings and holes shall be similarly treated, and those that are not to be used for rods, bolts, pins, screws, spikes, and the like or that will not subsequently be otherwise closed shall be tightly filled with treated plugs. Timber for floors and decks and that which is to be used in construction of split ring or shear plate connected trusses shall be well seasoned and thoroughly air dried before being incorporated in the work. This requirement shall apply to all material treated or untreated.

530.4 WORKMANSHIP

All lumber and timber shall be cut and framed to a close fit and shall have even bearing over the entire contact surfaces. No shimming will be permitted in making joints. Holes for drift pins in untreated lumber shall be bored with a bit 1/16 inch less in diameter than the pin or dowel. Holes for drift pins and dowels in treated lumber shall be bored with a bit of the same diameter as the pin or dowel. Holes for truss rods or bolts shall be bored with a bit 1/16 inch larger than the rod or bolt. Holes for lag screws shall be bored with a bit not larger than the base of the thread. In small timbers where the prevention of splitting is necessary, holes shall be bored for spikes with a bit having a diameter not larger than that of the spike. In the installation of metal timber connectors, care shall be exercised to insure that the connector is installed concentric with its corresponding bolt; and if more than one connector bolt is installed in any individual joint, all bolts in such joint shall be drawn up to an even and uniform tension. The grooves for split-ring and shear-plate connectors shall be drawn up to an even and uniform tension. The grooves for split-ring and shear-plate connectors shall be carefully cut to a uniform width and depth for full perimeter thereof. The dimensions of these grooves and the manner and means of cutting shall be as recommended by the manufacturer of the particular connector to be installed; and any special tool or equipment used in cutting the grooves shall be operated in the manner and at the speed similarly recommended. Toothed-ring and spiked-grind connectors shall be installed by means of pressure equipment of a type intended for the purpose. However, split-ring connectors shall not be forced on but shall be expanded to such extent as to readily slip over the core formed by the groove without damaging the wood. All bolts, unless otherwise indicated on the plans, shall be 3/4 inch in diameter or larger and shall be of sufficient length to project beyond the nut when the nut is drawn tight. Bolts shall be fitted at each end with either a malleable iron (ogee) washer or a steel plate at least 3 inches square and not less than 3/8 inch thick or as otherwise shown on the plans.

530.5 FRAMING

530.5.1 Mudsills shall be firmly and evenly bedded on solid material.

530.5.2 Sills and caps shall have a full even bearing on the pedestals, mudsills, posts, or piles. Caps and sills shall be securely drifted to the posts by drift bolts not less than 3/4 inch in diameter,

extending into the post by at least 9 inches, and set approximately in the center of the posts.

530.5.3 Bents shall be accurately aligned before the bracing is placed. Bracing shall be fastened at the ends and at each intersection by 3/4 inch bolts. Bracing shall be of such length as will provide a minimum distance of 8 inches between the outside bolt and the end of the brace.

530.5.4 In placing joints, the better edge shall be placed down. The elevation of the tops of adjacent joists shall not vary more than 1/8 inch. Outside joists shall have butt joints. Interior joists shall be lapped and shall extend the full width of the cap to obtain full bearing. Bridging between joists shall be solid and fastened to the joists near the top of the block and on each side of the bottom of the block. Bridging shall be accurately cut to fit closely between the joists.

530.5.5 Trusses when completed shall show no irregularity of line. Chords shall be straight and true from end to end in horizontal projection, and in vertical projection shall show a smooth curve through panel points conforming to the correct camber. Uneven and rough cuts at the points of bearing shall be cause for rejection of the piece containing the defect.

530.5.6 Laminated bridge floors shall be constructed with planks, as shown on the plans. The planks shall be laid with the better edge down.

530.6 PAINTING

The railing of timber bridges, including the posts, the entire outer edge of bridge decks except treated surfaces, and any other surfaces indicated on the plans to be painted, shall be painted as prescribed in Section 157. The surface of wooden guard rails above the ground shall be painted as prescribed in Section 157. The lumber shall be cut to fit and then the entire surface shall be given the specified prime coat. The remaining coats shall be applied after the structure has been erected.

530.7 MEASUREMENT AND PAYMENT

Timber structures will be measured as provided in the Bid Proposal. Where board measure is used, the quantity will be determined from nominal widths and thicknesses and the actual lengths of the pieces in the finished structure, except that in laminated timber flooring the number of laminations shall be the required number of the size specified after dressing and the length of each lamination shall be considered as the full width of length of the floor.

SECTION 540

CONCRETE BLOCK MASONRY STRUCTURES

540.1 GENERAL

Work to be done under this section shall consist of the construction of concrete block masonry walls incorporated into and being part of a building or structure, and free standing and retaining walls, constructed of concrete block masonry units. Wall heights, thickness, pilaster locations, reinforcing length, and other data shall be as shown on the plans, specified herein, and as specified in the Supplementary Specifications.

540.2 REFERENCES

540.2.1 This Publication:
SECTION 106

540.3 MASONRY UNITS

Unless otherwise specified and except for manhole construction, concrete block masonry shall be constructed of Grade N-I or N-II hollow masonry units.

540.4 MORTAR AND GROUT

Except as otherwise herein specified, all mortar and grout shall conform to Section 106. Mortar and grout for use in sewer manholes shall be prepared from Type II cement or approved equal. All work shall be executed in the best workmanlike manner and in full compliance with the applicable building ordinances. Masonry walls shall be laid true, level, and plumb in accordance with the plans. Surfaces on masonry units shall be clean, dry, and free from dirt when laid in the walls.

540.5 CONSTRUCTION

All concrete block units shall be dry when laid. During construction all partially laid walls, as well as units in storage, shall be protected from moisture. All concrete block units and any partially laid walls which become wet during the construction shall be permitted to dry for at least one week or longer if required by weather conditions before recommencing work. Proper masonry units shall be used to provide for all openings in walls, bond beams, lintels, pilasters, etc., with a minimum of unit cutting. Where masonry unit cutting is necessary, all cuts shall be neat and regular and edges exposed in the finished work shall be cut with a power-driven abrasive saw. Where no bond pattern is shown, the wall shall be laid up in straight uniform course with regular running bond. Intersecting masonry walls and partitions shall be bonded by staggering the joints to form a masonry bond and the use of 1/4 inch minimum diameter steel ties at 24 inches o.c. maximum. Where stack bond is indicated on the plans, approved metal ties shall be furnished and installed as directed by the ENGINEER. Mortar joints shall be straight, clean, and uniform in thickness. Unless otherwise specified or detailed on the plans, horizontal joints shall be approximately 3/8 inch thick with full mortar coverage on the face shells, shall have vertical joints buttered well for a thickness equal to the face shell of the block, and these joints shall be shoved tightly so that the mortar bonds to both blocks. Masonry to be plastered shall have all mortar joints trowel cut flush. Exposed walls shall have joints tooled with a round bar (or V shaped bar) to produce a dense, slightly concave surface well bonded to the block at the edges. Tooling shall be done when the mortar is partially set but still sufficiently plastic to bond. All tooling shall be done with a tool which compacts the mortar, pressing the excess mortar out of the joint rather than dragging it out. If it is necessary to move a block so as to open a joint, the block shall be removed from the wall, cleaned, and set in fresh mortar.

540.6 PLACING REINFORCING STEEL

Reinforcing steel and wire mesh type of reinforcing shall be placed as indicated on the plans. Splices shall be lapped a minimum of 40 diameters, except that dowels other than column dowels need be lapped only 30 diameters. Column dowels shall lap 50 diameters. Outside horizontal steel shall lap around corners 40 diameters and be carried through columns unless otherwise shown on the plans. Inside horizontal steel shall extend as far as possible and bend into corner core. A dowel shall be provided in the foundation for each vertical bar. Where horizontal courses are to be filled, metal stops shall be used. Use of paper stops will not be permitted. All horizontal reinforcing steels shall be laid in a course of bond beam blocks filled with grout. Vertical cores containing steel shall be filled solid with grout and thoroughly rodded. Where knockout blocks are not used, steel shall be erected and wired in place before 3 courses have been laid. Vertical cores

at steel locations shall be filled as construction progresses. Where knockout blocks are used, vertical cores at steel locations shall be filled in lifts of not more than 4 feet. The maximum height of pour shall be 8 feet. Cores shall be cleaned of debris and mortar and shall have reinforcing steel held straight in place. If ordered by the ENGINEER, inspection and cleanout holes shall be provided at the bottom of each core to be filled. Reinforcing shall be inspected prior to placing grout.

540.7 CURING

Newly constructed masonry shall be kept damp for at least five days with a nozzle regulated fog spray sufficient only to moisten faces of the masonry but not of such quantity as to cause water to flow down over the masonry or by the use of approved curing compounds or as specified in the Supplementary Specifications.

540.8 MEASUREMENT AND PAYMENT

540.8.1 Concrete block masonry walls shall be measured by the wall area in square feet, as determined by the mathematical product of the length, including pilasters, and the height from the top of the footing to the top of the wall. Payment shall be made on the Bid Proposal's unit price per square foot, as per specified wall or block width and design (hollow, concrete filled blocks or reinforced).

540.8.2 The footing shall be measured separately by the cubic yard of plain or reinforced concrete as specified on the drawings and appropriate bid items.

SECTION 541

BRICK MASONRY STRUCTURES

541.1 GENERAL

Work to be done under this section shall consist of the construction of brick masonry walls incorporated into and being part of a building or structure, and free standing and retaining walls, constructed of brick masonry units. Wall heights, thickness, pilaster locations, reinforcing, length, and other data shall be as shown on the plans.

541.2 REFERENCES

541.2.1 This Publication:
SECTION 106
SECTION 108

541.3 MATERIALS

Unless otherwise specified, brick masonry shall be constructed of Grade MW brick as described in Section 108 and cement mortar as described in Section 106.

541.4 BRICKLAYING

541.4.1 The amount of wetting will depend on the rate of absorption of the brick at the time of laying. When being laid, the brick shall have suction sufficient to hold the mortar and to delete the excess water from grout and shall be sufficiently damp so that the mortar will remain plastic enough to permit the brick to be leveled and plumbed after being laid without breaking the mortar bond.

541.4.2 Brick work shall be plumb, level, straight, and true to dimensions shown on the plans. Such work shall start, where feasible, at the least important corner of wall and the CONTRACTOR shall request an early inspection of the work by the ENGINEER. All pattern work, bonds, or special details indicated on the drawings shall be accurately and uniformly executed. Face bonding shall be as shown on the drawings but, if not shown, shall be running bond for standard size brick and approximately 1/3 bond for oversize brick and approximately 1/4 bond for modular brick. All bed and head joints shall be solidly filled with mortar at the time of laying.

541.4.3 Unless otherwise shown or detailed on the plans, the thickness of mortar joints shall be uniformly 1/2 inch.

541.4.4 Face brick shown to be laid in stack bond shall have the center lines of vertical joints plumb and the brick laid equidistant from the center line with not more than 1/8 inch variation in the width of these joints. The brick in each separate "stack" shall not vary more than 1/8 inch in length, but the separate "stack" may vary in width of stacks.

541.4.5 When mortar has slightly stiffened, solidly fill with mortar all interstices between bricks and between bricks and other materials and also fill all line pin holes. Jointing and tooling shall be done before mortar has stiffened.

541.4.6 Masonry to be plastered shall have all mortar joints trowel cut flush.

541.4.7 Masonry to be painted and not shown to be tooled or raked shall have all joints carefully and evenly struck with a trowel.

541.4.8 Masonry to be left exposed without paint or plaster shall have all mortar joints carefully and evenly tooled with a metal jointing tool of a type as approved by the ENGINEER. Masonry shown or indicated to have raked joints shall have the joints raked out 3/8 inch deep, then tooled with a flat jointing tool, then brushed with a stiff nonmetallic brush. Sack-rubbing or wiping finished masonry with rags will not be permitted.

541.5 PROTECTION

Protect all sills, ledges, offsets, other materials, etc. from droppings of mortar during construction. Protect the tops of all unfinished masonry from rain by using water-repellent covering, such as roofing felt or tar paper. Protect the surfaces of wall, piers, etc. from mortar droppings or splashes at scaffold heights.

541.6 CURING

Finished masonry shall not be wetted except when exposed to extreme hot weather or hot wind, and then only by using a nozzle-regulated fog spray sufficient only to dampen the face but not of such quantity to cause water to flow down over the masonry.

541.7 REINFORCED GROUTED BRICK MASONRY

541.7.1 Mortar in all bed joints shall be held back 1/4 inch from edges of brick adjacent to grout space or shall be beveled back and upward from grout space. The thickness of head and bed joints shall be as hereinbefore specified

or shown. Head joints specified or shown to be less than 5/8 inch thick shall be solidly filled with mortar as bricks are laid. Head joints 5/8 inch or more in thickness may have mortar sufficient only to form dams to retain the grout. Bed joints shall not be deeply furrowed with the trowel. All brick shall be shoved at least 1/2 inch into place. One outer tier may be carried up not more than 12 inches before grouting, but the other tier shall be not more than 4 inches high before placing the grout.

541.7.2 Grout shall be thoroughly agitated and mixed to eliminate segregation before being placed. All interior grout spaces shall be filled with grout and immediately puddled or swished with a stick or rod (not a trowel) sufficiently to cause the grout to flow into all interstices between the bricks and to fully encase the reinforcing steel. Wherever possible, grouting shall be done from the inside face of exterior masonry. If any grout contacts the finished masonry, it shall be immediately removed and the surface cleaned.

541.7.3 In masonry which is more than 2 tiers in thickness, including pilasters and columns, the interior shall be of whole or half bricks placed into grout with not less than 3/4 inch of grout surrounding each brick or half brick. Except at the finish course, all grout shall be stopped 1 1/2 inches below the top of both outer tiers.

541.7.4 Where necessary to stop off a longitudinal run of masonry, it shall be done only by racking back 1/2 brick length in each course and stopping grout 2 inches back of the rack. Toothing will not be permitted unless special approval is given by the ENGINEER.

541.7.5 Reinforcing steel shall be accurately placed in strict accordance with the drawings and notes thereon. Vertical steel shall be held firmly in proper position. Where necessary, this shall be done by means of frames or other suitable devices. Horizontal steel may be placed as the work progresses.

541.8 MEASUREMENT AND PAYMENT

When the Bid Proposal contains items for construction of free standing brick masonry walls and brick masonry retaining walls, the unit of measurement shall be the linear foot for the various designated wall heights and wall thickness. Otherwise the work will have been incorporated as part of a lump sum bid item for a building or structure.

SECTION 550

METAL RAILING

550.1 GENERAL

This work shall consist of furnishing and erecting metal railing in substantial compliance with the specifications and the dimensions, lines, and grades shown on the plans or established by the ENGINEER.

550.2 REFERENCES

550.2.1 ASTM
A 36
A 120

550.2.2 AASHTO
M 183

550.2.3 This Publication:
SECTION 157
SECTION 520

550.3 MATERIALS

The materials shall be in conformity with the following requirements:

550.3.1 Railing shall be fabricated from the material designated on the plans. If not so designated, railing may be fabricated from either steel or aluminum alloy.

550.3.2 The design of railings shall conform to the particular type or types designated on the plans. The CONTRACTOR will be required to submit complete shop details and erection plans for all railings.

550.3.3 Steel Railings--Unless otherwise shown on the plans, structural steel for steel railings, including bolts, shall conform to the requirements of AASHTO M 183 (ASTM A 36).

550.3.4 Pipe Railings--Steel pipe for pipe railing members shall be black seamless steel pipe of the size, dimensions and details shown on the plans, and conforming to the requirements of ASTM A 120. The hydrostatic test will not be required.

550.3.5 Aluminum Railings--Aluminum alloys for all castings, tubing, structural shapes, plates, bolts and washers shall conform to the requirements of ASTM specifications for alloys for the various items required as designated on the plans.

550.4 CONSTRUCTION REQUIREMENTS

550.4.1 STEEL RAILINGS:

550.4.1.1 Steel railings shall be fabricated and erected in accordance with the pertinent requirements for the fabrication and erection of structural steel under Section 520. Steel railings shall be erected in accordance with the details shown on the plans. Care shall be taken to obtain accurate vertical and horizontal alignment.

550.4.1.2 Unless otherwise provided on the plans, all steel railing members shall be painted with one prime coat of red lead and linseed oil and two coat of aluminum paint. The paint shall conform to the requirements for paint under Section 157. The preparation of surfaces and the application, protection, and drying of paint coatings shall conform to the requirements for painting under Section 157. Surface adjacent to field welds shall not be painted until after the welds are completed. Surfaces that are inaccessible after erection shall be painted and allowed to dry before the member is erected. After erection, all abrasions and omissions shall be recoated.

550.4.2 PIPE RAILINGS:

Construction methods for pipe railings shall conform to construction methods for steel railings as outlined above.

550.4.3 ALUMINUM RAILINGS:

550.4.3.1 Aluminum railings shall be fabricated and erected in accordance with the requirements for fabrication and erection of structural steel under Section 520 with the following modifications:

550.4.3.1.1 Cutting--Material 1/2 inch thick or less may be sheared, sawed, or milled. Material over 1/2 inch thick shall be sawed or milled. Cut edges shall be true, smooth, and free from excessive burrs or ragged breaks. Reentrant cuts shall be filleted by drilling prior to cutting. Flame cutting will not be permitted.

550.4.3.1.2 Bending--To facilitate bending, material may be heated to a temperature not exceeding 400 degrees F. for a period not to exceed 30 minutes.

550.4.3.1.3 Rivet and Bolt Holes--Rivet and bolt holes may be drilled to finished size or may be subpunched smaller than the nominal diameter of the fastener and reamed to size. The amount by which the diameter of the subpunched hole is

smaller than that of the finished hole shall be at least one-quarter of the thickness of the piece. The finished diameter of holes shall be not more than 7 percent greater than the nominal diameter of the fastener except:

550.4.3.1.3.1 Slotted holes shall be as called for on the drawings.

550.4.3.1.3.2 Anchor bolt holes may be up to 50 percent greater than the nominal bolt diameter with a maximum of 1/2 inch greater than the nominal bolt diameter.

550.4.3.2 Driven heads of rivets shall be flat head or cone head. Flat heads shall have a diameter not less than 1.4 and a height not less than 0.4 times the nominal rivet diameter. Cone heads shall have a diameter not less than 1.4 and an overall height not less than 0.65 times the nominal rivet diameter. The included angle at the apex of the cone head shall be approximately 127 degrees.

550.4.3.3 Rivets shall be driven with squeeze riveters when practical or otherwise by pneumatic hammers of approved size. Rivets 1/2 inch or less in diameter shall be driven cold. Rivets over 1/2 inch diameter may be driven hot. Rivets shall be heated in a hot air type furnace providing uniform temperatures throughout the rivet chamber and equipped with automatic temperature controls. The rivet temperature shall be held between 990 degrees F. and 1,050 degrees F. for not less than fifteen minutes and not more than one hour before driving. Hot rivets shall be transferred from the furnace to the work and driven with a minimum loss of time.

550.4.3.4 Welding shall be done by an arc welding process in which no welding flux is used. The type of electrodes shall be as noted on the railing drawings. Welding shall be done only as called for on such drawings.

550.4.3.5 Tubular vertical balusters may be fastened to horizontal rails by expanding the tubes where they pass through the rails. The holes shall be drilled to a size not more than 1/32 inch greater than the nominal diameter of the baluster tube. A standard self-feeding tapered roll expander shall be used. Balusters shall be expanded to a tight fit in all rails.

550.4.3.6 The portion of the aluminum alloy anchor bolts which is intended to be exposed outside the finished concrete surface shall be given a protective coating of grease or heavy oil before the concrete is placed.

550.4.3.7 Contact with Other Materials--Where aluminum alloys come in contact with other metals or with concrete, the contacting surfaces shall be thoroughly coated as required on the railing drawings.

550.4.3.8 Except as required above for contact with other materials, aluminum railings shall not be painted.

550.4.3.9 Aluminum railings shall be erected in accordance with details shown on the plans. Care shall be taken to obtain accurate horizontal and vertical alignment.

550.5 MEASUREMENT AND PAYMENT

550.5.1 Measurement of metal railing will be made by one of the following methods:

550.5.1.1 By lineal measured foot from end to end of the metal railing in place.

550.5.1.2 By computed weight, in pounds, based on details shown on the fabricator's approved shop drawings or from detailed plans prepared by the ENGINEER when shop drawings are not required.

550.5.1.3 By the unit of the completed metal railing.

550.5.2 Metal railing will be paid for at the Bid Proposal's unit price per lineal foot or pound, or per lump sum.